Chapter Thirty-eight

ROADSIDE SAFETY

BUREAU OF DESIGN AND ENVIRONMENT MANUAL

Chapter Thirty-eight
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The ideal roadway would be entirely free of any roadside obstructions or other hazardous conditions. This is rarely practical because of natural, economic, and environmental factors. Chapter 38 presents clear zone distances which should adequately provide a clear recovery area for about 80% of the errant vehicles that run off the road, and the chapter provides criteria for the use of roadside barriers, median barriers, and impact attenuators where providing the clear zone is not practical. The chapter also discusses the use of cost-effective methodologies to determine roadside safety treatments.

This Section presents the IDOT application of roadside safety decisions based on project type and appurtenance type.

38-1 APPLICATION

38-1.01 Project Type

The following summarizes the use of the *BDE Manual* for roadside safety applications based on the project type or project scope of work:

1. New Construction/Reconstruction Projects. Chapter 38 presents the roadside safety criteria for all new construction/reconstruction projects.
2. 3R Non-Freeway Projects. Chapter 49 presents the roadside safety criteria for 3R rural and urban highway non-freeway projects.
3. 3R Freeway Projects. Chapter 50 presents the roadside safety criteria for 3R freeway projects.
4. Highway Safety Improvement Projects. The IDOT Bureau of Safety Engineering is responsible for identifying the project scope of work for highway safety improvement projects that use the Federal-aid funds set aside for highway safety improvements. The scope of work may include roadside safety improvements. In this case, the designer will use the criteria in Chapter 38 with the specific application determined on a case-by-case basis considering:
    - the crash patterns at the site,
    - the project scope as outlined by the Bureau of Safety Engineering,
    - project budget, and
    - estimated construction costs.
5. Work Zones. Chapter 55 presents the roadside safety criteria for work zones.

38-1.02 Appurtenance Type

The following summarizes the Department's roadside safety responsibilities based on type of appurtenance:

1. Bridge Rails. The IDOT Bureau of Bridges and Structures is responsible for establishing Department criteria for the selection and design of all bridge rails. The Bureau of Design and Environment (BDE) is responsible for the roadside barrier and terminal section approaching the bridge rail.

2. Traffic Control Devices. The Bureau of Operations and the Bureau of Bridges and Structures are jointly responsible for establishing Department criteria for the design of structural supports for traffic control devices (e.g., breakaway bases for large signs). For the location of traffic control devices, the Bureau of Operations determines the initial placement, and the road designer ensures that the proposed location is compatible with the roadway design.

3. All Other Appurtenances. BDE is responsible for establishing Department criteria for all other roadside safety appurtenances (e.g., roadside barriers, median barriers, impact attenuators, luminaires).

38-2 DEFINITIONS

1. Back Slope. The side slope created by connecting the ditch bottom, shelf, or shoulder at the hinge point, upward and outward, to the natural ground line.

2. Barrier Terminals. End treatments for both roadside barriers and transitions to other types of barriers (e.g., to bridge rails).

3. Barrier Warrant. A criterion that identifies an area of concern which should be shielded by a traffic barrier, if judged to be practical. The warrant may be based on IDOT/AASHTO guidelines, on a "cost-effective" assessment, or on engineering judgment.

4. Concrete Barrier. A rigid barrier constructed in a narrow median where no deflection distance is available and which can accommodate most vehicular impacts without penetration.

5. Critical Parallel Slope. Fill sections with front slopes steeper than 1V:3H that cannot be safely traversed by a run-off-the-road vehicle. Depending on the encroachment conditions, a vehicle on a critical slope may overturn.

6. End Treatments. The terminal devices for roadside barriers, including both the approaching and departing ends.

7. Experimental System. A roadside barrier, end terminal, or impact attenuator which has performed satisfactorily in full-scale crash tests but has not been installed in sufficient locations or exposed to traffic for a sufficient time to adequately evaluate its in-service performance.

8. Front Slope. The side slope created by connecting the shoulder or shelf at the hinge point, downward and outward, to the ditch bottom or natural ground line.

9. Gating. A term used to describe barrier end treatments which are designed to allow controlled penetration by an impacting vehicle.

10. Impact Angle. For a longitudinal barrier, the angle between a tangent to the face of the barrier and a tangent to the vehicular path at impact. For an impact attenuator, it is the angle between the axis of symmetry of the impact attenuator and a tangent to the vehicular path at impact.

11. Impact Attenuator (Crash Cushion). A protective device used to safely shield roadside hazards, typically point obstacles, from approximately head-on impacts by errant vehicles.

12. Length of Need. Total length of a longitudinal barrier, measured with respect to the centerline of roadway, needed to shield an area of concern. The length of need is measured to the last point of full-strength rail.

13. Median Barrier. A longitudinal barrier used to prevent an errant vehicle from crossing the median of a divided highway thereby preventing head-on collisions between opposing traffic.

14. Non-Recoverable Parallel Slope. Slopes which can be safely traversed but upon which an errant vehicle is unlikely to recover. The run-off-the-road vehicle will likely continue down to the toe of the slope. For most embankment heights, if a front slope is between 1V:3H (inclusive) and 1V:4H (exclusive), it is considered a non-recoverable parallel slope.

15. Non-Redirective. A descriptive term which indicates that the roadside safety device will not redirect an impacting vehicle but will, rather, “capture” the vehicle (e.g., sand barrels) or allow the vehicle to pass through (e.g., breakaway sign supports).

16. Operational System. A roadside barrier, end terminal, or crash cushion that has performed satisfactorily in full-scale crash tests and has demonstrated satisfactory in-service performance.

17. Parallel Slopes. Front and back slopes for which the toe runs approximately parallel to the roadway.

18. Pocketing. The potential for a vehicle impacting a redirective device to undergo relatively large lateral displacements within a relatively short longitudinal distance.

19. Recoverable Parallel Slope. Slopes that can be safely traversed and upon which a motorist has a reasonable opportunity to regain control of the vehicle. Front slopes 1V:4H and flatter are considered recoverable.

20. Redirective. A term which indicates that the roadside safety device is designed to redirect an impacting vehicle approximately parallel to the longitudinal axis of the device.

21. Roadside Barrier. A longitudinal barrier (e.g., guardrail, concrete barrier) used to shield roadside hazards. A longitudinal barrier may occasionally be used to shield pedestrians from vehicular traffic.

22. Roadside Clear Zones. The area provided beyond the edge of traveled way for the recovery of errant vehicles, which should be clear of any non-traversable hazards or fixed objects.

23. Roadside Hazards. A general term to describe roadside features that cannot be safely impacted by a run-off-the-road vehicle. Roadside hazards include both fixed objects and non-traversable roadside features (e.g., rivers).

24. Severity Index. A number from zero to ten used to categorize crashes by the probability of their resulting in property damage, personal injury, or fatality, or any combination of these possible outcomes.

25. Shy Distance. The distance from the edge of traveled way beyond which a roadside object will not be perceived as an immediate hazard by the typical driver, to the extent that the driver will change vehicular placement or speed.

26. Side Slope. A ratio used to express the steepness of a slope adjacent to the roadway. The ratio is expressed as vertical to horizontal (V:H).

27. Sloping Curb. A longitudinal element placed at the edge of traveled way to provide delineation, to control drainage, to manage access, and to outline corner islands. Sloping curbs have a height of 6 in (150 mm) or less with a sloping face of approximately 45°.

28. Toe of Slope. The intersection of the front slope or back slope with the natural ground line or ditch bottom, before any rounding is applied.

29. Top of Slope. The intersection of the back slope with the natural ground line, before any rounding is applied.

30. Transverse Slopes. Front and back slopes for which the toe runs approximately perpendicular to the flow of traffic on the major roadway. Transverse slopes are typically formed by intersections between the mainline and entrances, median crossovers, or side roads.

31. Vertical Curb. A longitudinal element placed at the edge of the traveled way to provide delineation, to control drainage, to manage access, and to minimize right-of-way acquisition. Vertical curbs range in height between 6 in and 10 in (150 mm and 250 mm) with a face steeper than 3 vertical to 1 horizontal.

38-3 ROADSIDE CLEAR ZONES

38-3.01 Background

The clear zone widths presented in this *Manual* are based on limited empirical data that has then been extrapolated to a wide range of conditions. Therefore, the distances imply a degree of accuracy that does not exist. They do, however, provide a good frame of reference for making decisions on providing a safe roadside area. Each application of the clear zone distance must be evaluated individually, and the designer must exercise good judgment.

When using the recommended clear zone distances, the designer should consider the following:

1. Project Scope of Work. The clear zone distances in Section 38-3 apply to all freeway projects and to new construction/reconstruction projects on non-freeways. Chapter 49 presents the criteria for 3R projects on non-freeways.

2. Context. If a formidable obstacle lies just beyond the clear zone, it may be appropriate to remove or shield the obstacle if costs are reasonable. Conversely, the clear zone should not be achieved at all costs. Limited right-of-way (see Item 4 below) or unacceptable construction costs may lead to installation of a barrier or perhaps no protection at all. As a general statement, the use of an appropriate clear zone distance is a compromise between maximum safety and minimum construction costs.

3. Boundaries. The designer should not use the clear zone distances as boundaries for introducing roadside hazards (e.g., bridge piers, non-breakaway sign supports, utility poles, landscaping features). These should be placed as far from the traveled way as practical.

4. Right-of-Way. Even for new construction/reconstruction projects, the availability of right-of-way may be a serious project issue. The acquisition of additional right-of-way solely to provide the clear zone distance may not be cost effective. If, on the other hand, the right-of-way width exceeds the design clear zone, this offers an opportunity to increase safety by removing all hazards within the right-of-way.

38-3.01 Clear Zone Values

Figure 38-3.A presents clear zone distances for design. The following discusses the use of Figure 38-3.A to determine the applicable clear zone.

38-3.01(a) Speed

The designer will use the design speed for the facility to determine the applicable clear zone from Figure 38-3.A.

Design Speed	Design Year ADT	Front Slopes			Back Slopes		
		1V:6H or Flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or Flatter
40 mph or less	Under 750	7 – 10	7 – 10	**	7 – 10	7 – 10	7 – 10
	750 – 1500	10 – 12	12 – 14	**	10 – 12	10 – 12	10 – 12
	1500 – 6000	12 – 14	14 – 16	**	12 – 14	12 – 14	12 – 14
	Over 6000	14 – 16	16 – 18	**	14 – 16	14 – 16	14 – 16
45 – 50 mph	Under 750	10 – 12	12 – 14	**	8 – 10	8 – 10	10 – 12
	750 – 1500	12 – 14	16 – 20	**	10 – 12	12 – 14	14 – 16
	1500 – 6000	16 – 18	20 – 26	**	12 – 14	14 – 16	16 – 18
	Over 6000	18 – 20	24 – 28	**	14 – 16	18 – 20	20 – 22
55 mph	Under 750	12 – 14	14 – 18	**	8 – 10	10 – 12	10 – 12
	750 – 1500	16 – 18	20 – 24	**	10 – 12	14 – 16	16 – 18
	1500 – 6000	20 – 22	24 – 30	**	14 – 16	16 – 18	20 – 22
	Over 6000	22 – 24	26 – 32*	**	16 – 18	20 – 22	22 – 24
60 mph	Under 750	16 – 18	20 – 24	**	10 – 12	12 – 14	14 – 16
	750 – 1500	20 – 24	26 – 32*	**	12 – 14	16 – 18	20 – 22
	1500 – 6000	26 – 30	32 – 40*	**	14 – 18	18 – 22	24 – 26
	Over 6000	30 – 32*	36 – 44*	**	20 – 22	24 – 26	26 – 28
65 – 70 mph	Under 750	18 – 20	20 – 26	**	10 – 12	14 – 16	14 – 16
	750 – 1500	24 – 26	28 – 36*	**	12 – 16	18 – 20	20 – 22
	1500 – 6000	28 – 32*	34 – 42*	**	16 – 20	22 – 24	26 – 28
	Over 6000	30 – 34*	38 – 46*	**	22 – 24	26 – 30	28 – 30

* *Clear zones may be limited to 30 ft for practicality and to provide a consistent roadway template.*
** *See procedure in Section 38-3.02(b).*

Notes:

1. *All distances are measured from the edge of the traveled way.*
2. *For clear zones, the "Design Year ADT" will be the total ADT for both directions of travel for the design year. This applies to both divided and undivided facilities. Traffic volumes will be based on a 20-year projection from the anticipated date of construction.*
3. *The values for "back slopes" only apply to a section where the toe of the back slope is adjacent to the shoulder. See Figure 38-3.B(d). For sections with roadside ditches, see Section 38-3.04.*
4. *The values in the figure apply to tangent sections of highway. See the discussion in Section 38-3.02(e) for possible adjustments on horizontal curves.*
5. *The values in the figure apply to all uncurbed sections and curbed sections in rural areas. See Section 38-3.01(f) for curbed sections in urban areas.*

RECOMMENDED CLEAR ZONE DISTANCES (ft)
(New Construction/Reconstruction)
(US Customary)

Figure 38-3.A

Design Speed	Design Year ADT	Front Slopes			Back Slopes		
		1V:6H or Flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or Flatter
60 km/h or less	Under 750	2.0 – 3.0	2.0 – 3.0	**	2.0 – 3.0	2.0 – 3.0	2.0 – 3.0
	750-1500	3.0 – 3.5	3.5 – 4.5	**	3.0 – 3.5	3.0 – 3.5	3.0 – 3.5
	1500-6000	3.5 – 4.5	4.5 – 5.0	**	3.5 – 4.5	3.5 – 4.5	3.5 – 4.5
	Over 6000	4.5 – 5.0	5.0 – 5.5	**	4.5 – 5.0	4.5 – 5.0	4.5 – 5.0
70-80 km/h	Under 750	3.0 – 3.5	3.5 – 4.5	**	2.5 – 3.0	2.5 – 3.0	3.0 – 3.5
	750-1500	4.5 – 5.0	5.0 – 6.0	**	3.0 – 3.5	3.5 – 4.5	4.5 – 5.0
	1500-6000	5.0 – 5.5	6.0 – 8.0	**	3.5 – 4.5	4.5 – 5.0	5.0 – 5.5
	Over 6000	6.0 – 6.5	7.5 – 8.5	**	4.5 – 5.0	5.5 – 6.0	6.0 – 6.5
90 km/h	Under 750	3.5 – 4.5	4.5 – 5.5	**	2.5 – 3.0	3.0 – 3.5	3.0 – 3.5
	750-1500	5.0 – 5.5	6.0 – 7.5	**	3.0 – 3.5	4.5 – 5.0	5.0 – 5.5
	1500-6000	6.0 – 6.5	7.5 – 9.0	**	4.5 – 5.0	5. 0 – 5.5	6.0 – 6.5
	Over 6000	6.5 – 7.5	8.0 – 10.0*	**	5.0 – 5.5	6.0 – 6.5	6.5 – 7.5
100 km/h	Under 750	5.0 – 5.5	6.0 – 7.5	**	3.0 – 3.5	3.5 – 4.5	4.5 – 5.0
	750-1500	6.0 – 7.5	8.0 – 10.0*	**	3.5 – 4.5	5.0 – 5.5	6.0 – 6.5
	1500-6000	8.0 – 9.0	10.0 – 12.0*	**	4.5 – 5.5	5.5 – 6.5	7.5 – 8.0
	Over 6000	9.0 – 10.0*	11.0 – 13.5*	**	6.0 – 6.5	7.5 – 8.0	8.0 – 8.5
110 km/h	Under 750	5.5 – 6.0	6.0 – 8.0	**	3.0 – 3.5	4.5 – 5.0	4.5 – 5.0
	750-1500	7.5 – 8.0	8.5 – 11.0*	**	3.5 – 5.0	5.5 – 6.0	6.0 – 6.5
	1500-6000	8.5 – 10.0*	10.5 – 13.0*	**	5.0 – 6.0	6.5 – 7.5	8.0 – 8.5
	Over 6000	9.0 – 10.5*	11.5 – 14.0*	**	6.5 – 7.5	8.0 – 9.0	8.5 – 9.0

* *Clear zones may be limited to 9.0 m for practicality and to provide a consistent roadway template.*
** *See procedure in Section 38-3.02(b).*

Notes:

1. *All distances are measured from the edge of the traveled way.*
2. *For clear zones, the "Design Year ADT" will be the total ADT for both directions of travel for the design year. This applies to both divided and undivided facilities. Traffic volumes will be based on a 20-year projection from the anticipated date of construction.*
3. *The values for “back slopes” only apply to a section where the toe of the back slope is adjacent to the shoulder. See Figure 38-3.B(d). For sections with roadside ditches, see Section 38-3.04.*
4. *The values in the figure apply to tangent sections of highway. See the discussion in Section 38-3.02(e) for possible adjustments on horizontal curves.*
5. *The values in the figure apply to all uncurbed sections and curbed sections in rural areas. See Section 38-3.02(f) for curbed sections in urban areas.*

RECOMMENDED CLEAR ZONE DISTANCES (m)
(New Construction/Reconstruction)
(Metric)

Figure 38-3.A

38-3.01(b) Design Year

For all freeway projects and non-freeway new construction/reconstruction projects, the design year will be 20 years from the anticipated date of construction.

38-3.01(c) Traffic Volumes

As indicated in Figure 38-3.A, the ADT influences the clear zone value. The figure is divided into ranges of traffic volumes and ranges of recommended clear zones. In general, the higher clear zones apply to the higher traffic volumes.

38-3.01(d) Side Slopes

The roadway side slope will influence the recommended clear zone distance from Figure 38-3.A. Figure 38-3.B presents a schematic of the general side slope configurations, which may include:

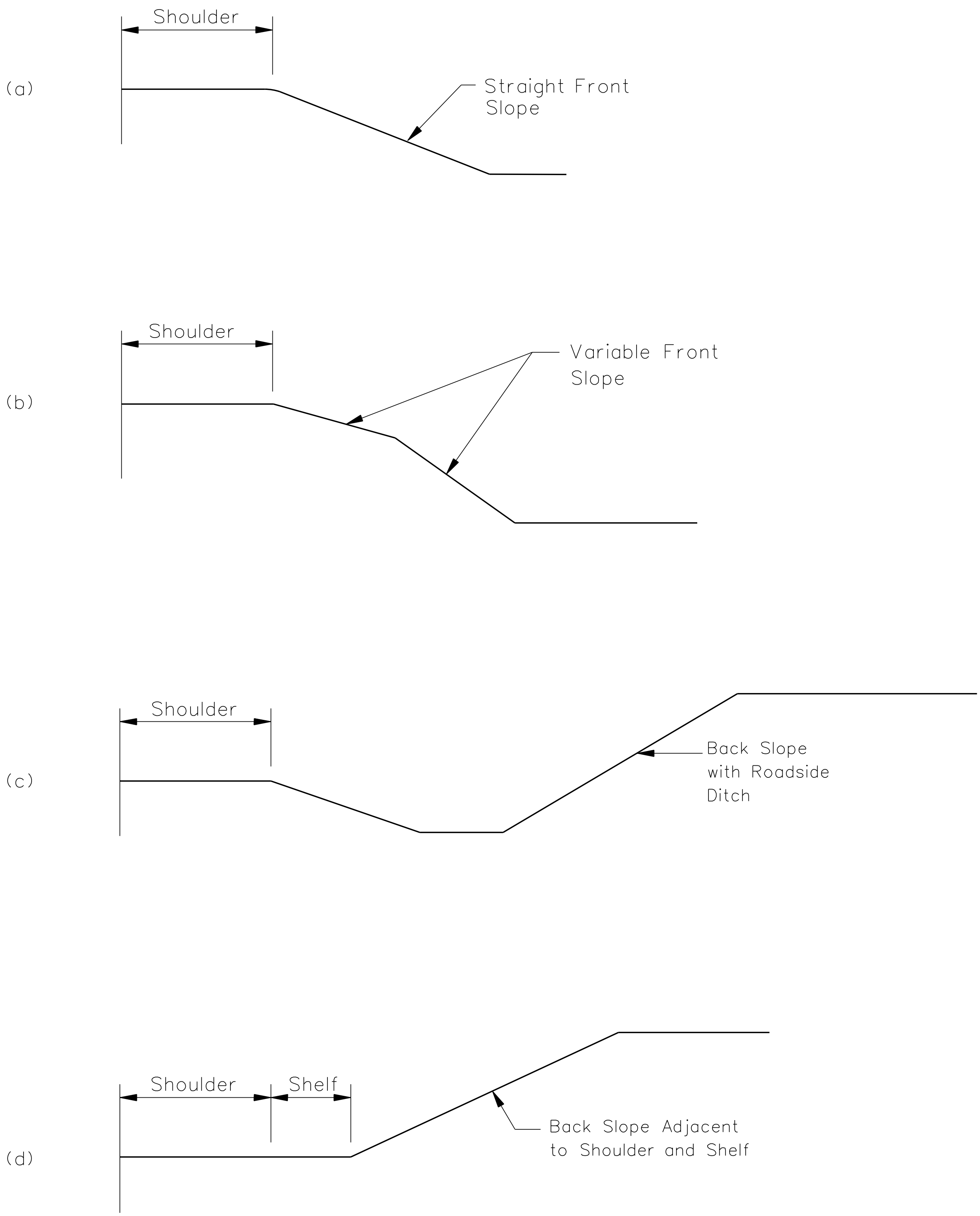
- a straight front slope,
- a variable or barn roof section,
- a section with a roadside ditch, or
- a section where the toe of the back slope is adjacent to the edge of shoulder.

Note: The values in Figure 38-3.A for back slopes only apply to a section as illustrated in Figure 38-3.B(d); they do not apply where a roadside ditch is present.

Many variables influence the selection of a clear zone distance for the various side slope configurations. Sections 38-3.03 and 38-3.04 discuss side slopes in detail.

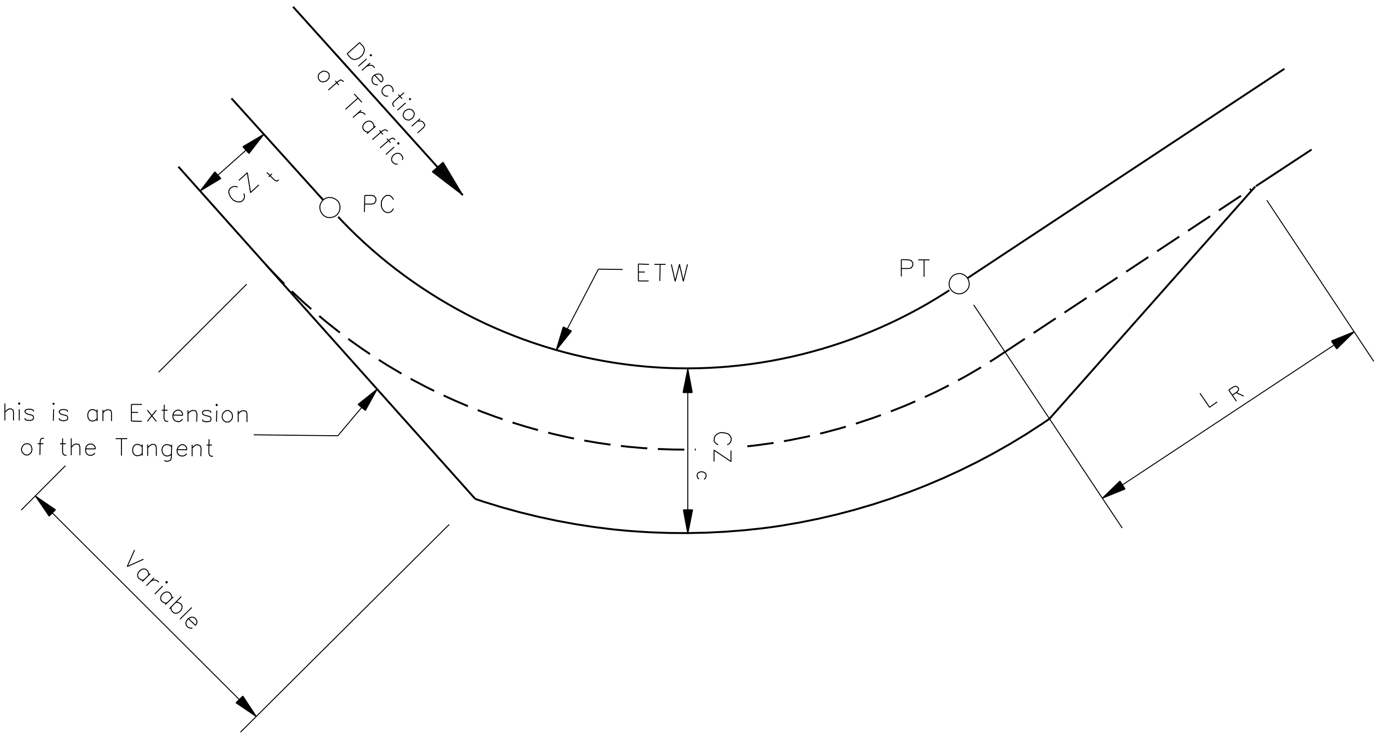
38-3.01(e) Alignment (Horizontal Curve Adjustment)

The clear zone values in Figure 38-3.A assume a tangent alignment. Horizontal curves may increase the angle of departure from the roadway and thus increase the distance the vehicle will need to recover. Desirably and if practical, the designer should adjust the tangent values to provide wider clear zones on the outside of horizontal curves. It is unnecessary, however, to purchase additional right-of-way solely to provide the clear zone adjusted for horizontal curvature. Where adjustments are determined to be cost effective, Figure 38-3.C illustrates the application of the clear zone adjustment on a curve. Figure 38-3.D provides recommended adjustments for clear zones on horizontal curves.



SIDE SLOPE CONFIGURATIONS

Figure 38-3.B



CZ_t = Clear Zone on Tangent Section
CZ_c = Clear Zone on Horizontal Curve
ETW = Edge of Traveled Way

Note: See Figure 38-6.E for L_R distances.

CLEAR ZONE WIDENING ON THE OUTSIDE OF HORIZONTAL CURVES

Figure 38-3.C

Radius (ft)	Design Speed (mph)						
	40	45	50	55	60	65	70
2860	1.1	1.1	1.1	1.2	1.2	1.2	1.3
2290	1.1	1.1	1.2	1.2	1.2	1.3	1.3
1910	1.1	1.2	1.2	1.2	1.3	1.3	1.4
1640	1.1	1.2	1.2	1.3	1.3	1.4	1.5
1430	1.2	1.2	1.3	1.3	1.4	1.4	
1270	1.2	1.2	1.3	1.3	1.4	1.5	
1150	1.2	1.2	1.3	1.4	1.5		
950	1.2	1.3	1.4	1.5	1.5		
820	1.3	1.3	1.4	1.5			
720	1.3	1.4	1.5				
640	1.3	1.4	1.5				
570	1.4	1.5					
380	1.5						

Notes:

1. *Adjustments apply to the outside of a horizontal curve only.*

2. *No adjustments are warranted for curve radii greater than 2860 ft.*

3. *The applicable clear zone distance on a horizontal curve is calculated by:*

$$CZ_c = (K_{cz})(CZ_t)$$

where: CZ_c = *clear zone on a curve, ft*
K_{cz} = *curve adjustment factor*
CZ_t = *clear zone on a tangent section from Figure 38-3.A, ft*

Round calculated CZ_c *up to the next highest 1 ft increment.*

4. *For curve radii intermediate in the figure, use a straight-line interpolation.*

5. *See Figure 38-3.C for the application of* CZ_c *to the roadside around a curve.*

CLEAR ZONE ADJUSTMENT FACTORS FOR HORIZONTAL CURVES (K_{CZ})
(US Customary)

Figure 38-3.D

Radius (m)	Design Speed (km/h)					
	60	70	80	90	100	110
900	1.1	1.1	1.1	1.2	1.2	1.2
850	1.1	1.1	1.1	1.2	1.2	1.3
800	1.1	1.1	1.1	1.2	1.2	1.3
750	1.1	1.1	1.1	1.2	1.2	1.3
700	1.1	1.1	1.2	1.2	1.2	1.3
650	1.1	1.2	1.2	1.2	1.3	1.4
600	1.1	1.2	1.2	1.2	1.3	1.4
550	1.1	1.2	1.2	1.3	1.3	1.4
500	1.1	1.2	1.2	1.3	1.3	1.4
450	1.2	1.2	1.3	1.3	1.4	
400	1.2	1.2	1.3	1.3	1.4	
350	1.2	1.2	1.3	1.4		
300	1.2	1.3	1.4	1.5		
250	1.3	1.3	1.4			
200	1.3	1.4				
150	1.4	1.5				
100	1.5					

Notes:

1. *Adjustments apply to the <u>outside</u> of a horizontal curve only.*

2. *No adjustments are warranted for curve radii greater than 900 m.*

3. *The applicable clear zone distance on a horizontal curve is calculated by:*

$$CZ_c = (K_{cz})(CZ_t)$$

where: CZ_c = *clear zone on a curve, m*
K_{cz} = *curve adjustment factor*
CZ_t = *clear zone on a tangent section from Figure 38-3.A, m*

Round calculated CZ_c *up to the next highest 0.5 m increment.*

4. *For curve radii intermediate in the figure, use a straight-line interpolation.*

5. *See Figure 38-3.C for the application of* CZ_c *to the roadside around a curve.*

CLEAR ZONE ADJUSTMENT FACTORS FOR HORIZONTAL CURVES (K_{CZ})
(Metric)

Figure 38-3.D

* * * * * * * * * *

Example 38-3.02(1)

Given: Design Speed = 55 mph
Design ADT = 3000
Horizontal curve with a radius of 2000 ft
Flat side slope

Problem: Find the clear zone adjusted for the horizontal curve.

Solution: From Figure 38-3.A, the clear zone on the tangent (CZ_t) = 20 ft.

From Figure 38-3.D, the curve correction factor (K_{cz}) = 1.2.
The clear zone for the curve (CZ_c) = (20)(1.2) = 24 ft (use 25 ft).

The transition length (equal to the runout length (L_R)) from Figure 38-6.E = 345 ft.

* * * * * * * * * *

38-3.01(f) Curbed Sections

The values in Figure 38-3.A apply to curbed and uncurbed sections of highway. Where curbs are present, the following additional considerations will apply:

1. Urban/Suburban Facilities. A minimum horizontal, obstruction-free clearance of 1.5 ft (500 mm) should be provided as measured from the gutter line of the curb. This applies to both vertical and sloping curbs, except that M2 (M5) curb will be treated as an uncurbed section. Because curbs are not considered to have re-directional capabilities, desirably and if practical, the designer should provide obstruction-free clearances beyond the curb greater than 1.5 ft (500 mm). Hazards behind curbs should be located outside of the clear zone shown for uncurbed roadways (i.e., Figure 38-3.A) when practical.

   As further discussed in Section 38-4, general Department policy is that roadside barriers are typically not warranted to shield hazards outside of the calculated clear zone. This also applies to hazards outside of the obstruction-free area behind curbs. However, special conditions may dictate otherwise. For example, a barrier may be required approaching all bridge rails on urban curbed facilities, unless the posted speed is 25 mph or less. Other exceptions, as determined on a case-by-case basis, may apply.

2. Rural Facilities. For specific field conditions, it may be acceptable to use sloping curbs on rural facilities. See Chapter 34. However, the clear zone will be determined assuming that the facility is uncurbed; i.e., the clear zone criteria presented in Chapter 38 will apply to all rural facilities whether curbed or uncurbed.

38-3.01(g) Lane Width

The clear zone distances in Figure 38-3.A are, theoretically, predicated upon a 12 ft (3.6 m) lane width. However, they will be used for any lane width.

38-3.01(h) Auxiliary Lanes

Auxiliary lanes are defined as any lanes beyond the basic through travel lanes that are intended for use by vehicular traffic for specific functions. These include turn lanes at intersections, truck-climbing lanes, weaving lanes, acceleration/deceleration lanes at interchanges, etc. The clear zone for auxiliary lanes will be determined as follows:

1. Turn Lanes at Intersections. Where the intersection is uncurbed, clear zones will be determined based on the design speed and traffic volumes associated with the through travel lanes; i.e., the presence of the turn lane is ignored when determining clear zones, provided that a minimum 10 ft (3.0 m) clear zone is maintained beyond the edge of the shoulder. Where the intersection is curbed, the criteria in Section 38-3.01(f) will apply; i.e., the minimum obstruction-free zone is 1.5 ft (500 mm) from the gutter line.

2. Auxiliary Lanes Adjacent to Mainline. Use the following clear zone applications for climbing lanes, acceleration/deceleration lanes, ramp terminals, weaving lanes, etc. Two independent clear zone determinations are necessary. First, the designer calculates the clear zone from the edge of the through traveled way based on the total traffic volume, including the auxiliary lane volume. Second, the designer calculates the clear zone from the edge of the auxiliary lane based on the traffic volume in the auxiliary lane. The clear zone distance that extends further will apply.

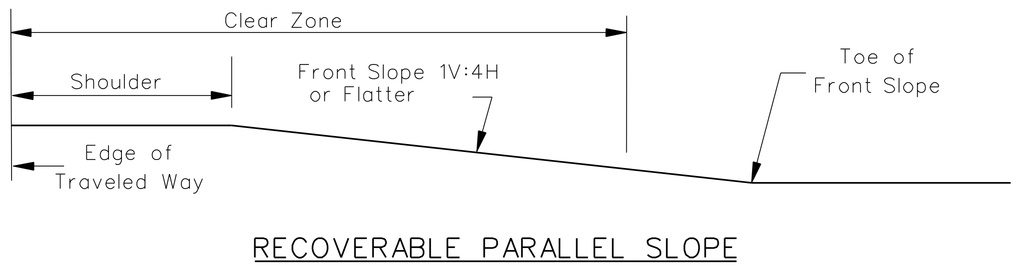
38-3.02 Front Slopes

Figure 38-3.B illustrates the two basic configurations for front slopes (i.e., straight slope or variable slope). Section 38-2 presents definitions of parallel front slopes that apply to clear zone determinations. Figure 38-3.E presents schematics for these definitions, and the following discusses the clear zone application in conjunction with Figure 38-3.A.

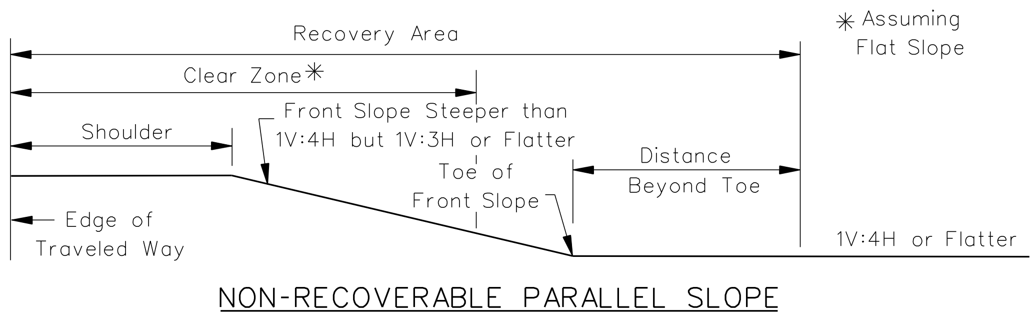
38-3.02(a) Recoverable Front Slopes

For parallel front slopes 1V:4H and flatter (Figure 38-3.E(a)), the recommended clear zone distance can be determined directly from Figure 38-3.A.

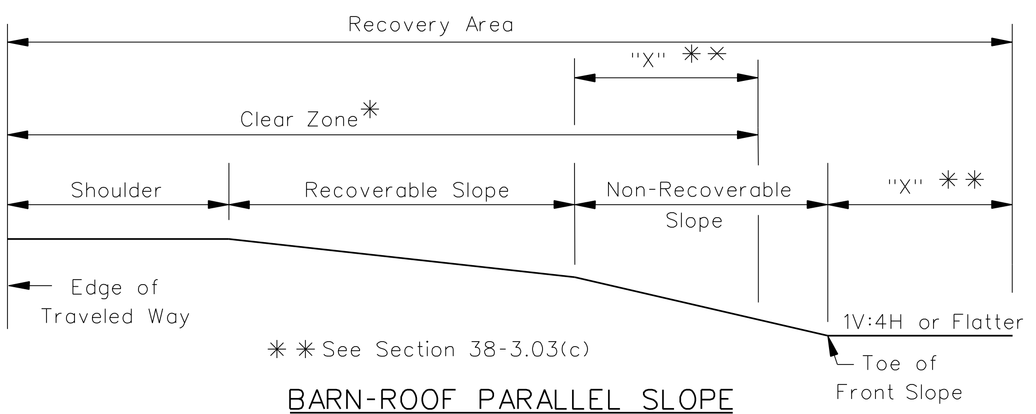
(a)



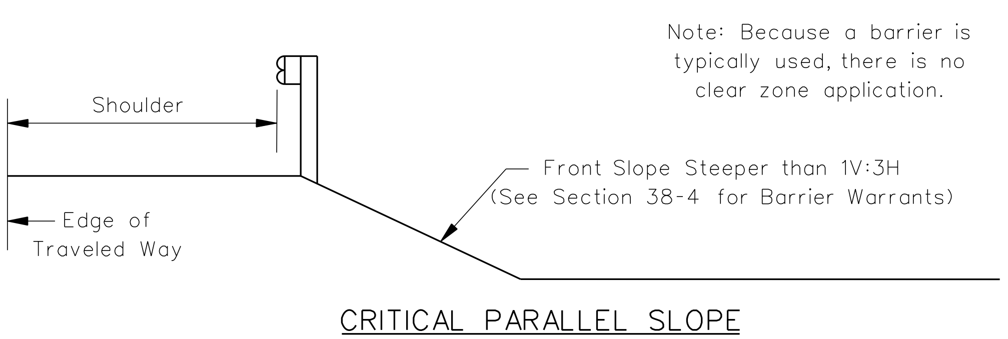
(b)



(c)



(d)



CLEAR ZONE APPLICATION FOR FRONT SLOPES (Uncurbed)

Figure 38-3.E

38-3.02(b) Non-Recoverable Front Slopes

For parallel front slopes steeper than 1V:4H but 1V:3H or flatter (Figure 38-3.E(b)), the recommended clear zone includes a distance beyond the toe of the slope. Use the following procedure to determine the clear zone:

1. Determine the clear zone for a 1V:6H or flatter slope from Figure 38-3.A for the applicable design speed and traffic volume.

2. To determine the recommended distance beyond the toe, subtract the shoulder width (or the distance from the edge of traveled way to the slope break) from the distance in Step 1.

3. If the distance in Step 2 is less than 10 ft (3 m), the minimum clear distance will be 10 ft (3 m) beyond the toe. If the distance in Step 2 is greater than 10 ft (3 m), the clear distance beyond the toe will be that distance or 15 ft (5 m), whichever is less.

38-3.02(c) Barn-Roof Front Slope (Recoverable/Non-Recoverable)

Barn-roof front slopes may be designed with a recoverable slope leading to a non-recoverable slope (Figure 38-3.E(c)). The distance from the break between the two slopes to the clear zone (noted as “X” on Figure 38-3.E(c)) should be applied as an addition outside the toe of the non-recoverable slope. This addition should be a minimum of 10 ft (3 m) wide; i.e., a clear area beyond the toe of slope (10 ft (3 m) minimum) will be needed where the clear zone extends beyond the break between the recoverable and non-recoverable slopes. The maximum clear zone area beyond the toe of slope will be 15 ft (5 m). If the distance from the edge of traveled way to the break between the two slopes is a minimum of 30 ft (9 m), no additional clear area will be required at the toe of slope.

38-3.02(d) Barn-Roof Front Slope (Recoverable/Recoverable)

Barn-roof front slopes are slopes designed with two recoverable slope rates — the second slope is steeper than the slope adjacent to the shoulder. This design requires less right-of-way and embankment material than a continuous, flatter slope. Although a weighted average of the slopes may be used, a simple average of the clear zone distances for each slope is sufficiently accurate, if the variable slopes are approximately the same width. If one slope is significantly wider, the clear zone computation based on that slope alone may be used.

38-3.02(e) Critical Front Slope

Front slopes steeper than 1V:3H are critical (Figure 38-3.E(d)). These typically require a barrier and, therefore, there is no clear zone application. See Section 38-4.

* * * * * * * * * *

Example 38-3.03(1) (Recoverable Front Slope)

Given: Front Slope — 1V:4H
Design Speed — 60 mph
Design ADT — 7000

Problem: Determine the recommended clear zone distance.

Solution: From Figure 38-3.A, the clear zone distance should be 36 ft to 44 ft. However, as indicated in a footnote to the figure, the clear zone distance may be limited to 30 ft based on specific site conditions to provide a more practical design.

Example 38-3.03(2) (Non-Recoverable Front Slope)

Given: Front Slope — 1V:3H
Shoulder Width — 10 ft
Design Speed — 60 mph
Design ADT — 7000

Problem: Determine the recommended clear zone distance.

Solution: The procedure in Section 38-3.03(b) for non-recoverable front slopes is used as follows:

1. From Figure 38-3.A, the clear zone for a front slope 1V:6H or flatter is 30 ft to 32 ft.

2. The recommended clear distance beyond the toe of the non-recoverable slope (1V:3H) is (30 ft to 32 ft) minus 10 ft yields (20 ft to 22 ft).

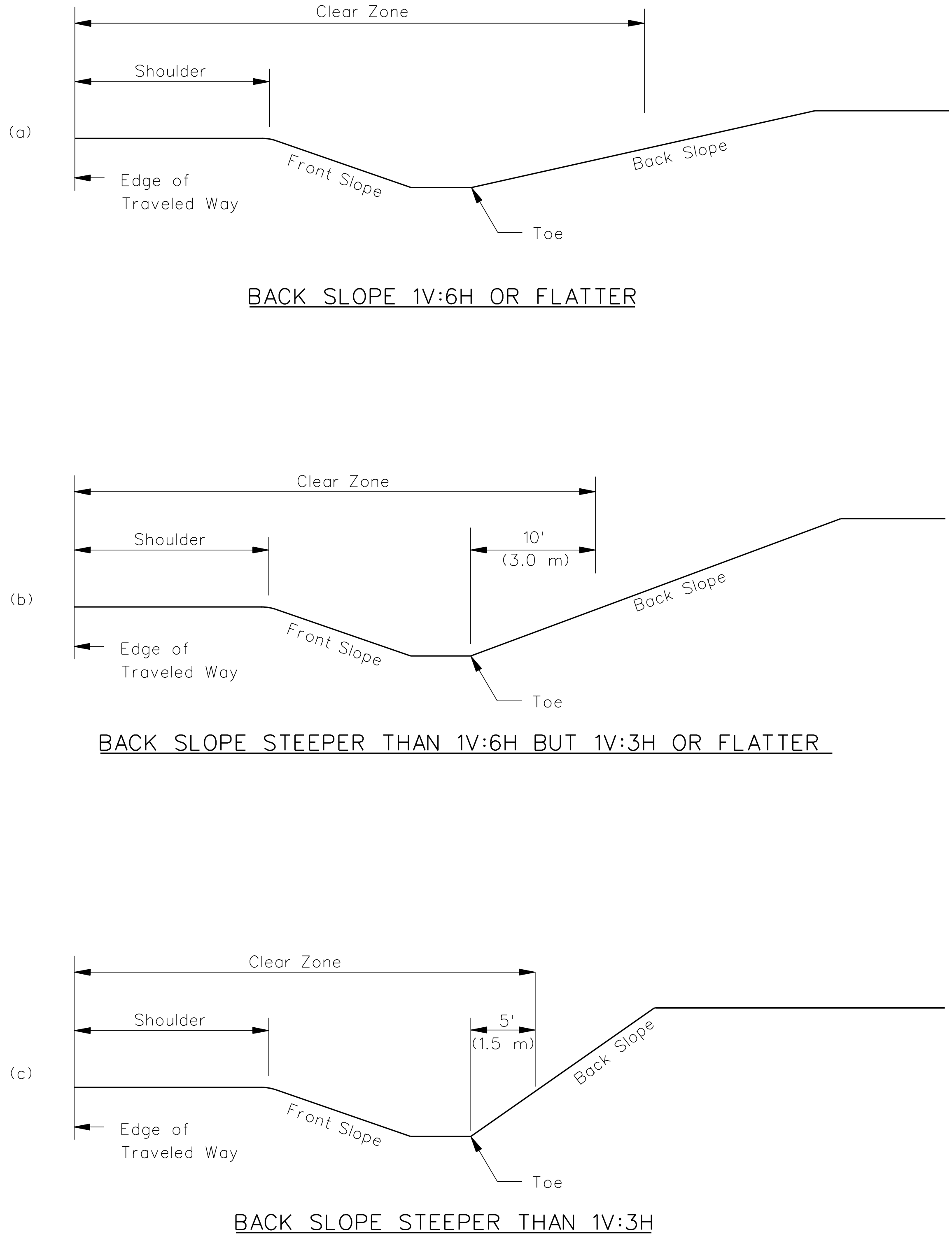
3. The calculated clear distance beyond the toe is 20 ft to 22 ft; however, the maximum distance is 15 ft.

* * * * * * * * * *

38-3.03 Roadside Ditches

Ditch sections, as illustrated in Figure 38-3.F, are typically constructed in roadside cut sections without curbs. The applicable clear zone across a ditch section will depend upon the front slope, the back slope, the horizontal location of the toe of the back slope, and various highway factors. The designer uses the following procedure to determine the recommended clear zone distance:

1. Check Front Slope. Use Figure 38-3.A to determine the clear zone based on the ditch front slope.



CLEAR ZONE APPLICATION FOR ROADSIDE DITCHES

Figure 38-3.F

2. <u>Check Location of the Toe of Back Slope</u>. Based on the distance from Step 1, determine if the toe of the back slope is within the clear zone. The toe of back slope is defined as the point at which the ditch rounding ends and the (uniform) back slope begins. If the toe is at or beyond the clear zone, then the designer usually need only consider roadside hazards within the clear zone on the front slope or within the ditch. If the toe is within the clear zone, the designer should evaluate the practicality of relocating the toe of back slope. If the toe of back slope will remain within the clear zone, Step 3 below will apply to ditch sections in earth cuts.

3. <u>Determine Clear Zone on Back Slope (Earth Cuts)</u>. If the toe of the back slope is within the clear zone distance from Step #1 above, a clear zone should be provided on the back slope. This clear zone will be a distance beyond the toe of back slope as follows:

    a. Where the back slope is 1V:6H or flatter (Figure 38-3.F(a)), treat the back slope as level and use the clear zone based on the front slope rate to determine the clear zone limit on the back slope.

    b. Where the back slope is steeper than 1V:6H but 1V:3H or flatter (Figure 38-3.F(b)), assume the vehicle cannot make it up to the top of the back slope, if the slope is at least 10 ft (3 m) wide. The initial 10 ft (3 m) beyond the toe of the back slope <u>or</u> the distance in Step 3a, whichever is less, should be clear of roadside hazards. Any obstacles beyond this point would be considered outside of the clear zone.

    c. Where the back slope is steeper than 1V:3H (Figure 38-3.F(c)), the initial 5 ft (1.5 m) beyond the toe of the back slope should be clear of roadside hazards.

4. <u>Clear Zones (Rock Cuts)</u>. In rock cuts with steep back slopes, no clear zone is required beyond the toe of back slope. However, the rock cut should be relatively smooth to minimize the hazards of vehicular snagging. If the face of the rock is rough or rock debris is present, a barrier may be warranted.

* * * * * * * * * *

<u>Example 38-3.04(1) (Ditch Section)</u>

Given: Design ADT = 7000
V = 60 mph
Front Slope = 1V:6H
Ditch Width = 4 ft
Back Slope = 1V:4H
Toe of back slope is 20 ft from edge of traveled way.
See Figure 38-3.G.

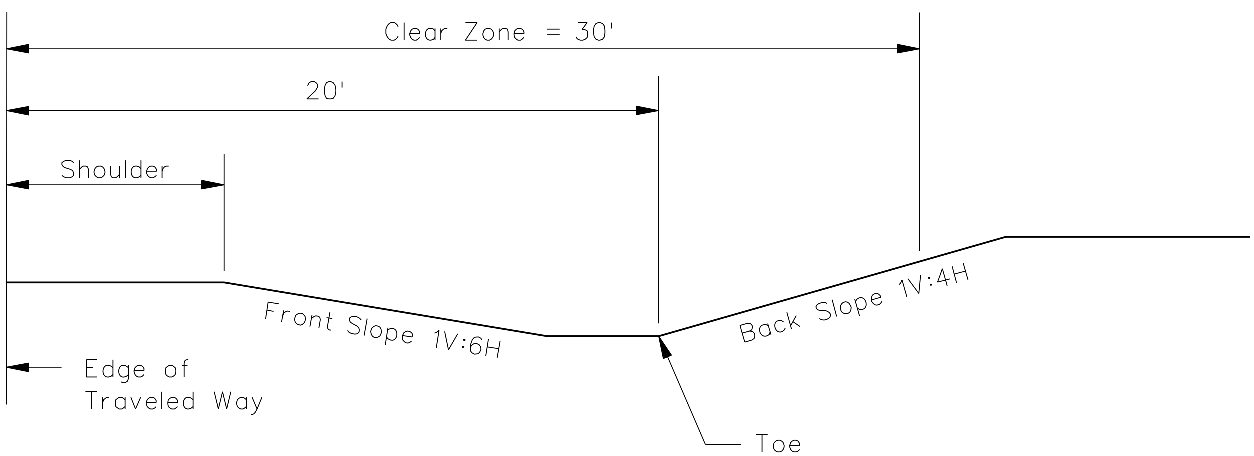
Problem: Determine the clear zone application across the ditch section.

Solution: Using the procedure in Section 38-3.04:

1. Check Front Slope. Figure 38-3.A yields a clear zone of 30 ft to 32 ft for a 1V:6H front slope. However, as indicated in the footnote, a 30-ft clear zone may be used.

2. Check Location of Toe of Back Slope. The toe of back slope is within the clear zone. Therefore, Step 3 applies.

3. Determine Clear Zone on Back Slope (Earth Cuts). With a 1V:4H back slope, the criteria in Step 3b in the procedure will apply. Based on these criteria, the initial 10 ft beyond the toe of back slope should be clear of roadside hazards. This yields a total distance of 35 ft from the edge of traveled way. Therefore, use the lower number from Step 2 and Step 3, which yields a 30 ft clear zone for the roadside.



CLEAR ZONE AT DITCH SECTION
(Example 38-3.04(1))

Figure 38-3.G

38-4 ROADSIDE BARRIER WARRANTS

38-4.01 Examples of Roadside Hazards

Examples of roadside hazards include:

- non-breakaway sign supports, non-breakaway luminaire supports, traffic signal poles, and railroad signal poles;
- concrete footings, etc., extending more than 4 in (100 mm) above the ground;
- bridge piers and abutments at underpasses and bridge parapet ends;
- culvert headwalls;
- trees with diameters greater than 4 in (100 mm) (at maturity);
- rough rock cuts;
- large boulders;
- critical parallel slopes (i.e., embankments);
- streams or permanent bodies of water (where the depth of water ≥ 2 ft (600 mm));
- non-traversable ditches;
- utility poles or towers;
- drainage appurtenances; and
- steep transverse slopes.

The severity of a specific roadside hazard will depend upon many factors. Appendix A of the AASHTO *Roadside Design Guide* presents Severity Indices (SI) for a variety of roadside hazards. The SI provides an indication of the relative severity of impacting the hazard compared to other roadside hazards.

38-4.02 Range of Treatments

If a roadside hazard is within the clear zone, the designer should select the treatment that is judged to be the most practical and cost-effective for the site conditions. The range of treatments include:

- eliminate the hazard (flatten embankment, remove rock outcroppings, etc.);
- redesign the hazard so it can be safely traversed (e.g., culvert grating);
- relocate the hazard to a point where it is less likely to be struck;
- where applicable, make the hazard breakaway (sign posts, luminaire supports);

- shield the hazard with a roadside barrier;
- delineate the hazard; or
- do nothing.

38-4.03 Warrant Methodologies

Warrants for roadside barriers imply that other options higher in the preference order for range of treatments (see Section 38-4.02) have first been considered. Whether objectively or subjectively, the decision will be based upon the traffic volumes, roadway geometry, proximity of the hazard to the traveled way, nature of the hazard, installation costs and, where applicable, crash experience. The following briefly discusses the Department's decision-making methods for barrier warrants.

38-4.03(a) Department Policy

For specific applications, the Department has adopted policies on warrants for roadside barriers. These are documented throughout Section 38-4. For example, Department policy is that, for bridge rail ends, an approaching roadside barrier will be installed unless the posted speed limit is less than 25 mph on an urban curbed section.

38-4.03(b) Cost-Effectiveness Method

Where practical, the designer should use an approved cost-effectiveness methodology to determine roadside barrier warrants. This will provide an objective means to analyze the myriad factors that impact roadside safety, and it will, in theory, allow the Department to allocate its resources to maximize the safety benefit to the traveling public. It will also promote uniformity of decision-making for roadside safety throughout the Department. The designer must use a cost-effectiveness methodology that has been approved by BDE. Currently, IDOT generally uses the cost-effectiveness methodology Roadside Safety Analysis Program (RSAP) presented in Appendix A of the AASHTO *Roadside Design Guide*.

38-4.03(c) Engineering Judgment Method

Until the development of cost-effectiveness models, barrier warrants were typically determined based on engineering judgment. With this approach, the designer first analyzes the site by a "relative severity" assessment — which is the greater hazard, the roadside barrier or the roadside hazard? Next, the designer subjectively evaluates the site-specific parameters (e.g., traffic volumes, design speed, location of hazard, barrier installation costs) to determine if a barrier installation is a reasonable and practical solution. If yes, a barrier is warranted; if no, the do-nothing alternative is selected. For example, it would probably not be practical to install a barrier to shield an isolated point obstacle (e.g., tree) located near the edge of the clear zone. The designer must realize that a barrier is also a hazard and, if a clear decision cannot be reached, the general rule of "when in doubt, leave it out" should apply.

It is acceptable to use engineering judgment to determine the warrants for roadside barriers for two conditions:

1. If the decision is obvious for a specific site, the designer may forego the use of a cost-effectiveness method and use engineering judgment to install or not install a roadside barrier.

2. If extenuating circumstances exist, the designer may override Department policies for barrier warrants or the results of a cost-effectiveness method, either to install or not install a roadside barrier. In this case, the designer must document the reasons for the decision. This documentation should include crash histories for the section of roadway, traffic volumes, posted speed, and roadway geometry.

38-4.04 Embankments

Figure 38-4.A presents barrier warrants for embankments.

38-4.05 Transverse Slopes

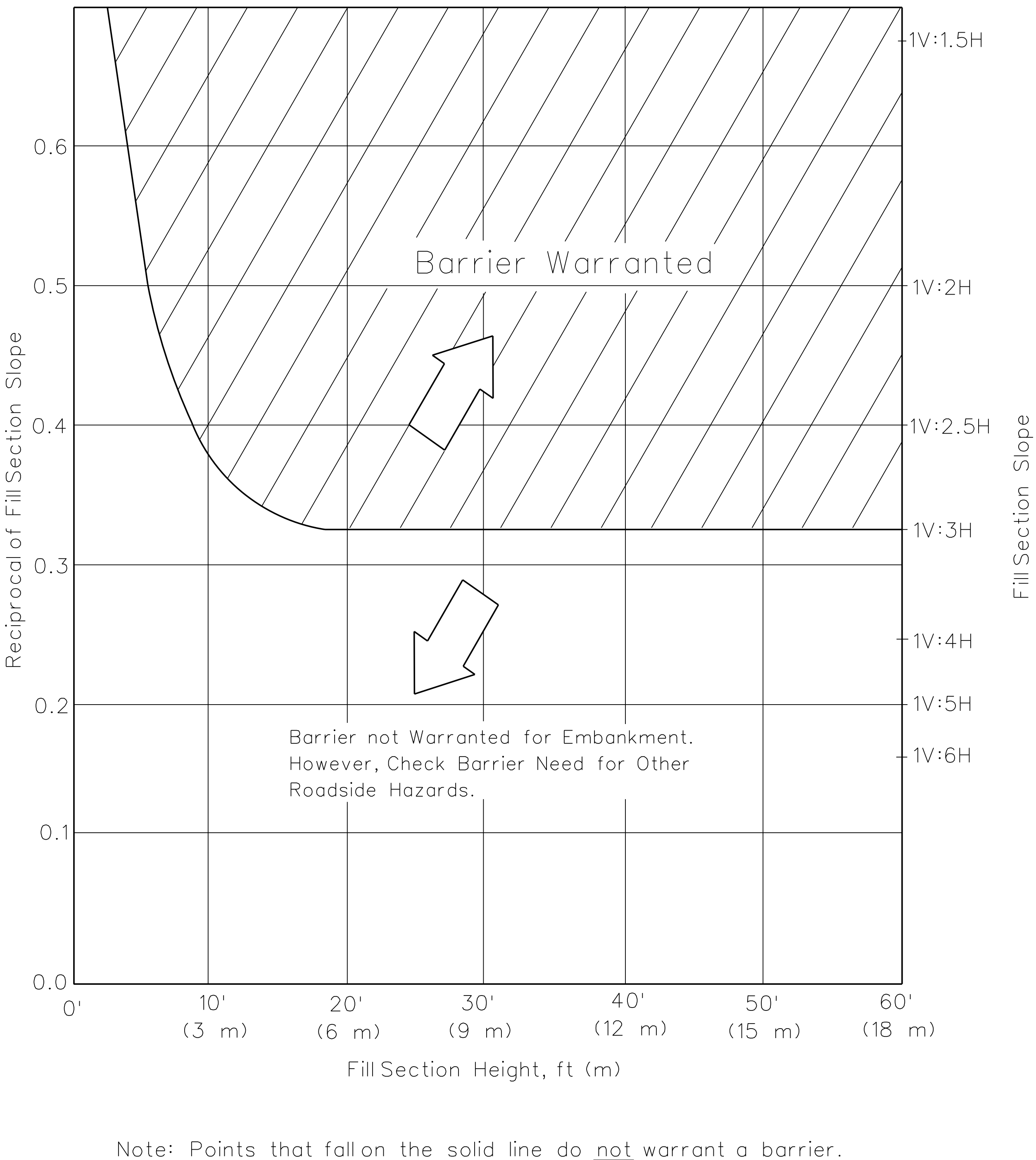
Where the mainline highway intersects an entrance, side road, or median crossing, a slope transverse to the mainline will be present. See Figure 38-4.B. Even at moderate speeds vehicles encountering transverse slopes can become airborne. Abrupt transverse slopes may also snag errant vehicles. In general, transverse slopes should be as flat as practical. Figure 38-4.C presents IDOT criteria for transverse slopes within the clear zone based on type of facility and design speed.

Figure 38-4.C presents both desirable (i.e., flatter) and acceptable (i.e., steeper) transverse slopes. The application at a specific site will depend upon an evaluation of many factors, including:

- height of transverse embankment,
- traffic volumes,
- design speed,
- presence of culverts and practicality of treating the culvert end (see Section 38-4.06),
- construction costs, and
- right-of-way and environmental impacts.

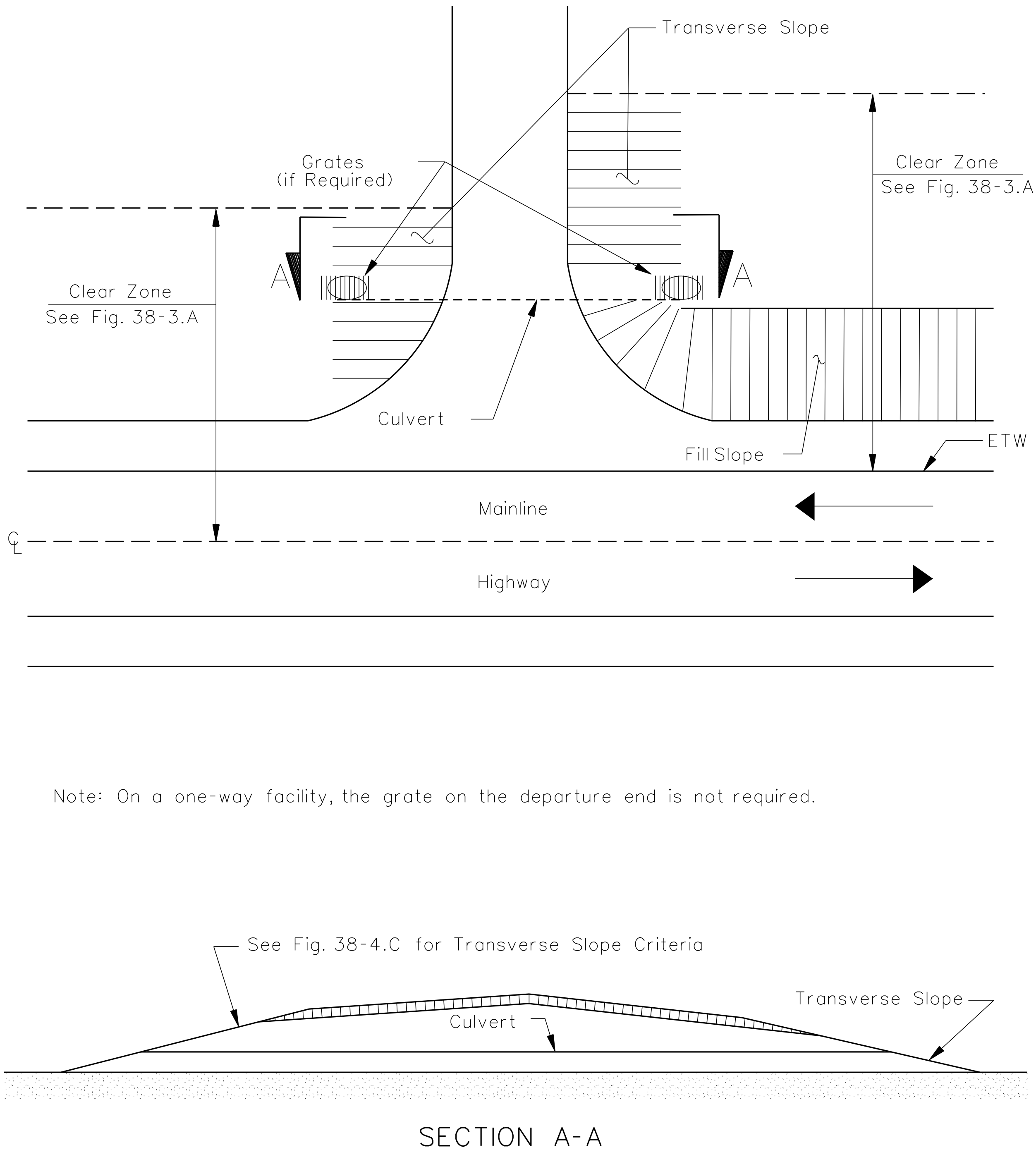
Although the 1V:10H transverse slope may be desirable, its practicality may be limited because of drainage structures, width restrictions, and maintenance problems associated with the long tapered ends of pipes or culverts. On arterial highways including freeways, however, the 1V:10H transverse slope should be used unless regrading of existing 1V:6H transverse slopes would require the installation of new drainage features.

If the criteria in Figure 38-4.C cannot be met, the designer should consider the installation of a roadside barrier.



BARRIER WARRANTS FOR EMBANKMENTS

Figure 38-4.A



TRANSVERSE SLOPES ON A TWO-LANE, TWO-WAY ROADWAY

Figure 38-4.B

Type of Facility	Desirable (V:H)	Acceptable (V:H)
Freeway	1:10	1:6
Rural Non-Freeways (V ≥ 50 mph (80 km/h))	1:10	1:6
Urban Non-Freeways (V ≥ 50 mph (80 km/h))	1:6	1:4
Urban and Rural Low-Speed Facilities (V ≤ 45 mph (70 km/h))	1:6	1:4

RECOMMENDED TRANSVERSE SLOPES

Figure 38-4.C

38-4.06 Roadside Drainage Features

Effective drainage is one of the most critical elements in the design of a highway or street. However, drainage features should be designed and constructed considering their consequences on run-off-the-road vehicles. Ditches, curbs, culverts, and drop inlets are common drainage system elements that should be designed, constructed, and maintained considering both hydraulic efficiency and roadside safety.

In general, the following options, listed in order of preference, are applicable to all drainage features:

1. Design or modify drainage structures so that they are traversable or present a minimal hazard to an errant vehicle.

2. If a major drainage feature cannot effectively be redesigned or relocated, shielding by a traffic barrier should be considered.

The *Illinois Drainage Manual* and Chapter 40 of the *BDE Manual* discuss the Department's practices for hydrology and hydraulics and for the physical design of roadside drainage structures. Sections 38-4.06(b) and (c) discuss the safety design of these structures.

38-4.06(a) Curbs

Curbs are typically used to control drainage or to protect erodible soils. Chapter 34 and the *IDOT Highway Standards* provide detailed information on the warrants and types of curbs used by the Department. Curbs may pose a roadside hazard because of their potential to adversely affect a run-off-the-road vehicle. When evaluating curbs relative to roadside safety, the designer should consider the following:

1. Design Speed. Facilities with a design speed greater than 45 mph (70 km/h) should be designed without curbs. However, if necessary, a sloping curb may be used. Facilities

with a design speed of 45 mph (70 km/h) or less may use either a sloping or vertical curb. See Chapter 34.

2. Roadside Barriers. The use of curbs with a roadside barrier is discouraged and, specifically, curbs higher than 6 in (150 mm) should not be used with a barrier. See Section 38-6.03.

3. Redirection. Curbs offer no safety benefits on high-speed roadways and should not be used to redirect errant vehicles.

4. M2 (M5) Curb. It is acceptable to use the 2 in (50 mm) high M2 (M5) curb in conjunction with a roadside barrier.

38-4.06(b) Cross Drainage Structures

Cross drainage structures convey water beneath the roadway and are designed to, among other objectives, prevent overtopping of the roadway. However, if not properly designed, they may present a hazard to run-off-the-road vehicles. The available roadside safety treatments for cross culverts are:

- extend the culvert opening beyond the clear zone with smooth, traversable earth graded transitions;
- provide a traversable end section;
- shield the culvert with a roadside barrier; or
- do nothing.

The following summarizes Department practices on the roadside safety treatment of cross drainage structures within the clear zone:

1. Pipe Diameter ≤ 36 in (915 mm). For these pipe sizes, provide an end treatment that matches the existing parallel slope.

2. Pipe Diameter > 36 in (915 mm) to ≤ 54 in (1400 mm). For these pipe sizes, provide a precast end section with grate.

3. Pipe Diameter > 54 in (1400 mm). For these pipe sizes, provide a special end section with a grate designed in accordance with Chapter 3 of the AASHTO *Roadside Design Guide* or provide a roadside barrier.

For pipe arches and elliptical pipes, the pipe rise will be used, rather than the equivalent round diameter, to determine the safety treatment. For box culverts, special designs for the end treatment will be required depending on the rise and span of the culvert. The type of treatment should be similar to that shown above for pipe culverts.

38-4.06(c) Parallel Drainage Structures

Parallel drainage culverts are those that are oriented parallel to the main flow of traffic. They are typically used under driveways, field entrances, access ramps, intersecting side roads, and median crossovers. Because an errant vehicle will impact the structure at approximately 90°, parallel drainage structures represent a potential hazard. Therefore, the designer must coordinate their design with that of the surrounding transverse slope (Section 38-4.05) to minimize the hazard.

The following summarizes Department practices on the roadside safety treatment of parallel drainage structures within the clear zone:

1. Pipe Diameter ≤ 18 in (450 mm). For these pipe sizes, a projecting end is acceptable.

2. Pipe Diameter > 18 in to ≤ 24 in (450 mm to ≤ 600 mm). For these pipe sizes, the end of the pipe should match the slope of the surrounding transverse slope. The opening to the pipe may remain.

3. Pipe Diameter > 24 in (600 mm). For these pipe sizes, the end of the pipe should match the surrounding transverse slope, and the designer should provide a grate across the opening. This will reduce wheel snagging if an errant vehicle impacts the pipe end. Figure 38-4.D presents a schematic of a design for grate protection of a parallel drainage structure.

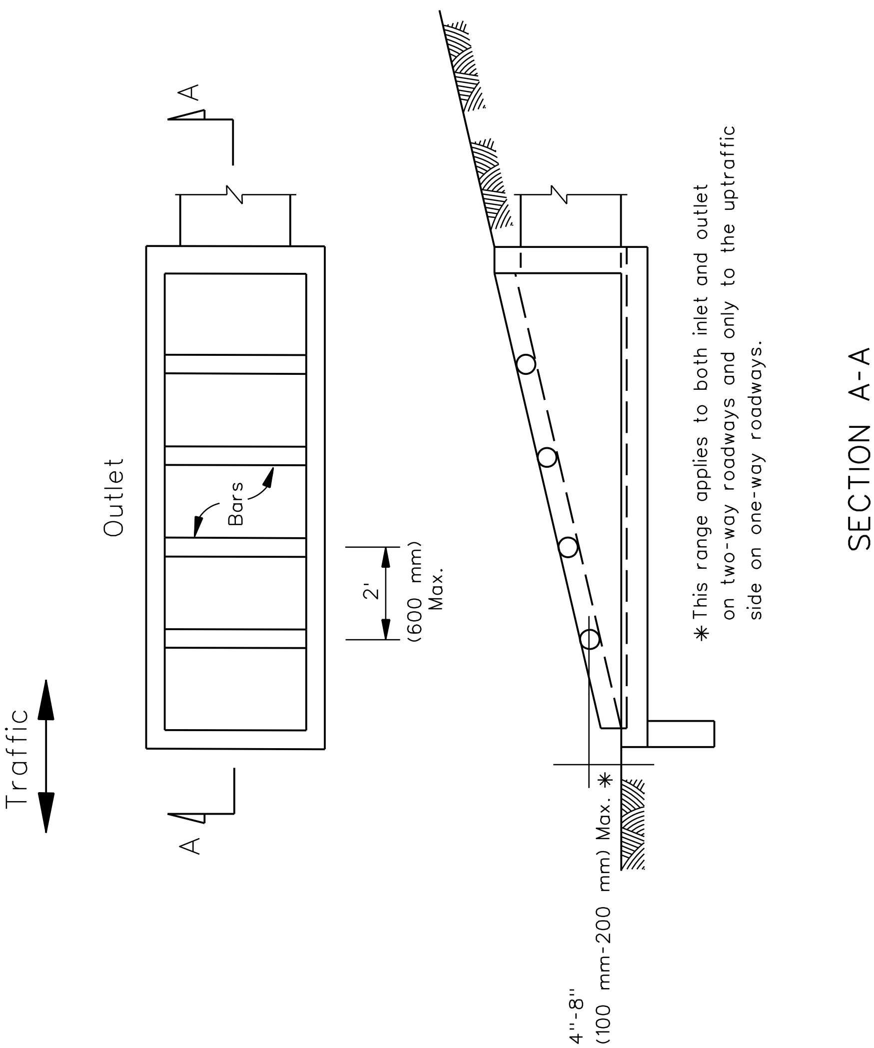
4. Pipe Arches and Elliptical Pipes. The pipe rise may be used rather than the equivalent round diameter to determine the appropriate end treatment in accordance with the above practices.

5. Box Culverts. The distance from the flow line of the culvert to the top of the headwall will be used to determine the appropriate treatment. If the span of the box culvert is > 5 ft (1.5 m), a special end treatment must be developed regardless of the height. Consult BDE for assistance in designing the end treatment.

6. Eliminate Exposed Ends. Parallel drainage structures may be closely spaced because of frequent driveways and intersecting roads. In such locations, it may be desirable to convert the open ditch into a closed drainage system and backfill the areas between adjacent driveways. This treatment will eliminate the ditch section and the transverse embankments with pipe inlets and outlets. However, care must be used to avoid creation of open frontage that would allow uncontrolled access.

38-4.06(d) Roadside Ditches (Earth Cuts)

The Department's configuration for roadside ditches in earth cuts, typically, is a trapezoidal ditch with the following dimensions:



DESIGN FOR PARALLEL DRAINAGE STRUCTURES
(Diameter > 24 in (600 mm))

Figure 38-4.D

- a 1V:6H front slope,
- a 4-ft (1.2-m) ditch width, and
- a 1V:3H back slope.

In the absence of other information (e.g., crash data), a roadside barrier is not warranted for the typical ditch configuration. The following additional information applies to roadside ditches in earth cuts:

1. Other Configurations. For other ditch configurations that introduce a more abrupt vehicular change in direction, the designer should refer to the AASHTO *Roadside Design Guide* to judge the acceptability of the proposed ditch. If this indicates a potential safety problem, the designer should conduct a cost-effectiveness analysis to determine:

    - if a revised ditch configuration is appropriate,
    - if a roadside barrier is warranted, or
    - if the do-nothing alternative is appropriate.

2. Deep Cuts. For earth cuts where the height of the cut from the bottom of the ditch is greater than 10 ft (3.0 m), the designer may consider using a 1V:2H back slope above the 10 ft (3.0 m) elevation to reduce costs.

38-4.07 Rock Cuts

The Department's configuration for rock cuts, typically, is the following:

- a 1V:6H front slope,
- a 1.5 ft (500 mm) plus width for falling rock ditch, and
- a 1V:0.25H back slope or as required by rock type.

If the toe of the rock cut is outside of the clear zone, a roadside barrier is not warranted unless other information (e.g., crash data) indicates otherwise. If the toe is within the clear zone, the designer should conduct a cost-effectiveness analysis to determine:

- if the rock cut should be relocated outside of the clear zone,
- if a roadside barrier is warranted, or
- if the do-nothing alternative is appropriate.

38-4.08 Bridge Rails

Barrier protection is normally warranted on all approach ends to bridge rails or parapets, and it is normally warranted on the departure ends of two-way roadways. No roadside barrier is needed on the departure end of a one-way roadway, unless a barrier is warranted for other reasons (e.g., front slopes steeper than 1V:3H).

Clear zones begin at the edge of the traveled way. As such, the departure end of a bridge parapet may or may not be within the clear zone of the opposing traffic, but because it is a formidable hazard introduced to the road side, it should be shielded. At a minimum, provide an approved end section and attachment to the bridge unless a cost-effective economic or other analysis shows shielding is not necessary. If other hazards (e.g., permanent body of water more than 2 ft (600 mm) deep) exist, then additional guardrail may be considered. To determine the required length of need for the opposing traffic, use the L_C for the approach end measured from the centerline. L_B and the departing point for L_R will be measured from the centerline; also see Figures 38-6.A and 38-6.B for definitions of L_C, L_B, and L_R.

38-4.09 Retaining Walls

Barrier protection is not necessary for the face of retaining walls that are considered smooth (i.e., the general absence of any unevenness in the wall that may adversely affect an impacting vehicle). Retaining walls built of sheet piling, H-piling with timber, or precast concrete inserts are usually considered smooth. In addition, the following will apply to the roadside safety aspects of retaining walls:

1. Flare Rates. Use the same rates as those for concrete barrier. See Figure 38-6.P.

2. End Treatment. Preferably, the retaining wall will be buried in a back slope thereby shielding its end. If this is not practical, use a crashworthy end treatment or impact attenuator. Where the design speed is 35 mph (60 km/h) or less, it is acceptable to transition the top of the wall from its normal height down to the ground line.

38-4.10 Traffic Control Devices

Traffic control devices include highway signs and traffic signals. If not properly designed and located, these devices may become a hazard to errant vehicles. The Bureau of Operations is responsible for the initial placement of traffic control devices, based on proper conveyance of information to the motorist, and the road designer reviews the location to ensure that it is compatible with the roadway design.

38-4.10(a) Highway Signs

For roadside safety applications, the following will apply to highway signs:

1. Design. The *Illinois Highway Standards* and *Sign Structures Manual* contain the Department's details for structural supports for traffic control devices.

2. Ground-Mounted Sign Supports. All supports for ground-mounted signs should be made breakaway or yielding, including those outside of the clear zone. Where practical, the designer should locate signs behind a roadside barrier that is warranted for other reasons. There should be adequate clearance to the back of the guardrail post to provide for the barrier dynamic deflection (see Section 38-6.02). In addition, sign

supports should not be placed in drainage ditches where erosion and freezing might affect the proper operation of breakaway supports. It is also possible that a vehicle entering the ditch will be inadvertently guided into the support.

3. Ground-Mounted Panel Signs. Large signs (over 50 ft^2 (5.0 m^2) in area) should have slipbase breakaway supports, whether within or outside the clear zone. Where practical, the designer should locate signs behind a roadside barrier that is warranted for other reasons. There should be adequate clearance to the back of the guardrail post to provide for the barrier dynamic deflection (see Section 38-6.02). Panel signs should not be placed in areas where the opportunity exists for them to be struck more than 9 in (230 mm) above the normal point of vehicular bumper impact, unless the sign is at least 7 ft (2.1 m) above the ground line. Normal bumper height is 18 in (460 mm). To avoid signs being struck at an improper height, they should be placed as follows:

    a. Front Slopes Flatter than 1V:4H. Signs should be located a minimum of 30 ft (9.0 m) from the edge of traveled way to the nearest edge of the sign.

    b. Front Slopes 1V:4H or Steeper. The nearest sign edge should be located 6 ft (1.8 m) from the edge of shoulder or 12 ft (3.6 m) from the edge of traveled way, whichever is greater.

   Breakaway sign supports should not be located in or near the flow line of ditches. If these supports are placed on a back slope, they should be offset at least 5 ft (1.5 m) from the toe of the back slope of the ditch.

4. Overhead Sign Supports. All overhead signs will use non-breakaway supports. Within the clear zone, the designer should conduct a cost-effectiveness analysis to determine if these structures should be protected with a roadside barrier or, where applicable, with an impact attenuator.

38-4.10(b) Traffic Signal Equipment

In general, the designer has limited options available in determining acceptable locations for the placement of signal pedestals, signal poles, pedestrian detectors, and controllers. Considering roadside safety, these elements should be placed as far from the roadway as practical. However, due to visibility requirements, limited mast-arm lengths, limited right-of-way, restrictive geometrics, or pedestrian requirements, traffic signal equipment often must be placed relatively close to the traveled way. The designer should consider the following when determining the placement of traffic signal equipment:

1. Clear Zones. If practical, the placement of traffic signals on new construction and reconstruction projects should meet the clear zone criteria (uncurbed) or obstruction-free clearance criteria (curbed) presented in Section 38-3.

2. Controller. In determining the location of the controller cabinet, the designer should consider the following:

a. The controller cabinet should be placed in a position so that it is unlikely to be struck by errant vehicles. It should be outside the clear zone or obstruction-free zone, if practical.

b. The controller cabinet should be located where it can be easily accessed by maintenance personnel.

c. The controller cabinet should be located so that a technician working in the cabinet can see the signal indications in at least one direction.

d. The controller cabinet should be located where the potential for water damage is minimized.

e. The controller cabinet should not obstruct intersection sight distance.

f. The power service connection should be reasonably close to the controller cabinet.

3. Pedestrians. If the signal pole must be located in the sidewalk, it shall be placed in a location that minimizes pedestrian conflicts. In addition, the signal pole shall not restrict access to curb ramps or reduce the sidewalk width below minimum. See Chapter 58.

4. Channelizing Islands. It is preferable not to place traffic signal equipment on islands within the roadway or intersection. However, the designer may need to use the islands, balancing safety, cost and practicality.

38-4.11 Luminaires

Because of the potential hazard posed to vehicles by roadside fixed objects, the general approach to lighting standards will be to use breakaway supports wherever possible. All new lighting standards located within the clear zone of a roadway where no pedestrian facilities exist will be placed on breakaway supports, unless they are located behind or on a barrier or protected by impact attenuators, which are necessary for other roadside safety reasons. Poles outside the clear zone on these roadways should be breakaway where there is a possibility of being struck by errant vehicles.

On roadways where pedestrian facilities exist, the designer should review the volume of pedestrian traffic to determine if a breakaway support will present a greater potential hazard to the pedestrian traffic than a non-breakaway support will to the vehicular traffic. Examples of locations where the hazard potential to pedestrian traffic would be greater include:

- transportation terminals,
- sports stadiums and associated parking areas,
- tourist attractions,

- school zones, or
- central business districts and local residential neighborhoods where the posted speed limit is 30 mph or less.

In these locations, non-breakaway supports will be used. Other locations that require the use of non-breakaway bases, regardless of the pedestrian traffic volume, are rest areas and weigh station parking lots and combined light and traffic signal poles.

38-5 ROADSIDE BARRIERS

38-5.01 Types

The *Illinois Highway Standards* present the details on the roadside barrier types used by the Department. Roadside barriers can be categorized as rigid, semi-rigid, and flexible. The following sections briefly describe each system and typical usage. Also, any items used on a case-by-case basis must comply with the appropriate NCHRP Report 350 criteria. Contact Bureau of Safety Engineering (BSE) for further information.

38-5.01(a) Steel Plate Beam Guardrail (Semi-Rigid Types)

Steel plate beam guardrail, commonly known as the W-beam system, with strong posts is a semi-rigid system. Blockouts are used to prevent a vehicle from snagging on the posts and to maintain rail alignment during a crash. The maximum post spacing is 6′-3″ (1905 mm) with the exception of special designs used for spanning low-fill culverts. Contact BSE for information regarding these special designs. The deflection distance is defined as the minimum distance that the back of a barrier system should be placed from a rigid object. For W-beam guardrail this is measured from the back of the post to the front face of the object; see Figures 38-6.K and 38-6.L. See Section 38-5.02 for information on where W-beam guardrail should be used.

The Department has adopted several variations of W-beam guardrail for various applications:

1. Type A. Type A guardrail uses the standard 6′-3″ (1905 mm) post spacing, and it is the most commonly used barrier system in Illinois. Type A has a deflection distance of 28 in (710 mm) between the back of post and the face of any rigid object behind the rail.

2. Type B. Type B guardrail uses half-post spacing of 3′-1½″ (953 mm) and has a deflection distance of 23 in (580 mm). It is used where the deflection distance for the Type A system is unavailable between the back of post and the face of any rigid object behind the rail.

3. Type D. See Section 38-7.02(b) for the use of this Type. It is a double-faced guardrail system used as a median barrier.

4. Attached to Headwalls. The Department has developed an adaptation of steel plate beam guardrail specifically for attachment to concrete headwalls near the edge of shoulder. Where feasible, Case IV of Highway Standard 630101 is preferred. It may be used on both new and existing culverts.

5. W-beam Guardrail at Quarter-post Spacing. This system uses quarter-post spacing of 1′-6¾″ (476 mm) and has a deflection distance of 14 in (360 mm). It is used where the deflection distance for the Type A or Type B system is unavailable. This post spacing is not shown in the *Illinois Highway Standards* and will require additional plan and contract information.

38-5.01(b) Concrete Barrier (Rigid Type)

Concrete barrier is a rigid barrier system that does not deflect upon impact. See Section 38-5.02 for information on where concrete barrier should be used.

For roadside applications, concrete barrier is normally applied with the safety shape on the traffic side and a vertical face on the back. Backfill behind the barrier for lateral support or use a special footing design (e.g., barrier tied to a concrete surface with reinforcing steel). Contact BSE for design parameters.

Depending on site conditions, the height of the concrete barrier may be either 32 in (815 mm) or 42 in (1070 mm). Consider using the taller barrier for locations with high truck volumes.

38-5.01(c) High-Tension Cable Barrier (Flexible Type)

Cable barrier is a flexible barrier system with weak posts. The posts are designed to bend over or break off upon impact. Cable barrier and other weak-post systems provide a forgiving impact with low deceleration forces exerted on vehicle occupants. See Section 38-5.02 for information on where cable barrier may be used.

IDOT requires the use of high-tension cable barriers that have passed NCHRP Test Level 4 crash test criteria. Deflection distances for these proprietary systems are greater than W-beam guardrail and vary depending on the product and the post spacing. See Section 38-6 for additional guidance on high-tension cable barriers.

38-5.01(d) Cable Road Guard Single Strand

Cable Road Guard Single Strand (Highway Standard 636001) is only used where the designer needs to inhibit unwanted vehicular encroachments. It should not be used as a roadside barrier. Do not place Cable Road Guard within the clear zone.

38-5.01(e) Other Systems

Many other roadside barrier systems are available which may have application at specific sites (e.g., thrie-beam guardrail). The designer should reference the AASHTO *Roadside Design Guide* for information on these systems. The Bureau of Design and Environment must approve the use of any system not included in the *Illinois Highway Standards*.

38-5.01(f) Aesthetic Treatments

Aesthetic treatments (e.g., timber railing) for guardrail and surface textures or patterns for concrete barrier can affect their safety performance and durability. Weathering steel guardrail has produced excessive rusting at lap joints and should not be installed. Contact BSE for information regarding suitability of any aesthetic treatments not included in the *Illinois Highway Standards*.

38-5.02 Barrier Selection

1. National Criteria. National Cooperative Highway Research Program Report 350 (NCHRP 350) includes the primary criteria for acceptance of roadside hardware. Devices meeting the AASHTO *Manual for Assessing Safety Hardware* (MASH) may also be considered.

2. Test Levels. Barriers that have passed Test Level 3 criteria of NCHRP Report 350 are required on high-speed roadways on the National Highway System and other State highways. Crash tests at Test Level 3 are conducted with both a small car and a pickup at 60 mph (100 km/h). Barriers tested at Test Level 2 criteria are conducted at 45 mph (70 km/h). Some concrete barriers and cable barriers have passed Test Level 4 criteria with a single-unit truck as the test vehicle. Some concrete barriers have passed test Level 5 criteria with a semi-tractor trailer as the test vehicle.

   The designer should consider the expected speeds and vehicle composition when selecting a barrier. Barriers that have passed Test Level 3 are often an appropriate choice. However, if the objective is a higher probability of containing large trucks, a barrier that has passed Test Levels 4 or 5 may be appropriate. Similarly, Test Level 2 barriers may be appropriate on lower speed roadways.

3. Dynamic Deflection. Dynamic deflection is another consideration. A barrier should be selected that provides adequate deflection space between the barrier and rigid objects behind the barrier; see Figure 38-6.K. Figure 38-6.L provides the deflection distances for the various systems.

4. Maintenance Considerations. Review the following maintenance considerations when selecting a barrier:

   - W-beam guardrail will require structural repair after hits that contain or redirect vehicles, and nuisance hits may inflict tears or kinks requiring repairs. In high-speed, high-traffic locations it may be unacceptable to have damaged sections of guardrail at locations where repair operations can create hazardous conditions for repair crews and can degrade traffic operations and safety.

   - Concrete barrier may be the best choice in locations where traffic and speed dictate that a damaged barrier and subsequent traffic disruption for repairs are not acceptable.

   - High-tension cable barriers will require repairs for virtually all nuisance and other hits. Depending upon the design specified many repairs may be performed without specialized or heavy equipment.

5. Preferred Barriers. W-beam guardrail is the preferred roadside barrier type for non-freeways and rural freeways where there is adequate deflection space. Where deflection space allows, and a Test Level 4 barrier is preferred, cable barrier may be used.

6. Concrete Barriers. Consider using concrete barrier for urban freeways and the following cases:

   - to shield objects close to the roadway where deflection space is limited;
   - where there is a high volume of heavy trucks;
   - to minimize repair and maintenance. Concrete barrier will often remain undamaged after an impact, while guardrail will require more frequent maintenance and repair;
   - to reduce headlight glare into nearby buildings or other sensitive areas;
   - to reduce headlight glare between frontage roads and the mainline, especially where the alignment directs headlights at opposing traffic; and
   - areas where it is especially critical to contain errant vehicles.

Figure 38-5.A summarizes the advantages and disadvantages of the roadside barriers used by IDOT and provides their typical usage. Figure 38-5.B summarizes the general selection criteria that apply.

System	Advantages	Disadvantages	Typical Usage
High Tension Cable Barrier	1. Lower initial cost. 2. More forgiving impact. 3. Weak-post systems maintain vehicle stability. 4. Relatively easy installation. 5. Remains functional after moderate collisions. 6. Some systems have features that make repair more efficient. 7. Minimizes snow drifting.	1. Larger deflection spaces needed. 2. Less likely to contain large vehicles than concrete barrier, although the systems used by IDOT have passed Test Level 4 (single-unit truck crash test). 3. Some potential for vehicles to under ride the barrier. 4. Cannot be used in conjunction with curbing. 5. Any impact requires repair.	1. Non-freeways. 2. Rural freeways. 3. Side hazards where deflection space is adequate and a Test Level 4 barrier is preferred.
W-Beam Guardrail	1. Lower initial cost. 2. High level of familiarity by maintenance personnel. 3. Can safely accommodate a wide range of impact conditions for passenger vehicles. 4. Relatively easy installation. 5. Remains functional after nuisance collisions. 6. Can be used in conjunction with curbing.	1. Less likely to contain large vehicles than concrete barrier or cable barrier. 2. At high-impact locations, will require frequent maintenance. 3. Will cause more snow drifting than cable barrier. 4. Hits that redirect or contain vehicles will require repair.	1. Non-freeways with narrow medians. 2. Rural freeways. 3. Side hazards where deflection space is adequate.
Concrete Barrier	1. Can accommodate most vehicular impacts without penetration. 2. No deflection distance required behind barrier. 3. Little or no damage sustained for most vehicular impacts; therefore, least need for maintenance. 4. Minimal vehicular under ride/ override potential for snagging potential.	1. Highest initial cost. 2. Can induce vehicular rollover. 3. For given impact conditions, highest occupant decelerations; therefore, least forgiving of barrier systems 4. Reduce performance where offset between traveled way and barrier exceeds 12 ft (3.6 m). 5. Increased snow drifting.	1. Urban freeways. 2. Where high traffic volumes are present. 3. Where high volumes of large vehicles are present.

ROADSIDE BARRIER SELECTION

Figure 38-5.A

Criteria	Comments
1. Performance Capability	Barrier must be structurally able to contain and redirect design vehicle.
2. Deflection	Adequate deflection space should be available so that the barrier can deflect on impact without contacting rigid objects behind the barrier.
3. Site Conditions	Slope approaching the barrier, slope behind the barrier, and distance from traveled way may preclude use of some barrier types.
4. Compatibility	Barrier must be compatible with planned terminal treatment and capable of transition to other barrier systems (e.g., bridge railing).
5. Cost	Standard barrier systems are relatively consistent in cost, but special-use systems can cost significantly more.
6. Maintenance	
a. Routine	Few systems require a significant amount of routine maintenance.
b. Collision Damage	W-beam guardrail will require the most extensive repair after a collision. Many high-tension cable barriers will require less extensive repair. Concrete barrier will have the least repair requirements after a collision.
c. Nuisance Hits	High-tension cable barrier will require the most frequent attention for nuisance hits (e.g., mowers, snowplows, minor vehicular encroachments). W-beam guardrail will require repairs where nuisance hits causes kinks or tears. Concrete barrier will seldom require repairs for nuisance hits.
d. Materials Storage	The fewer the number of different systems used, the fewer inventory items/storage space required. High-tension cable barrier specifications allow a number of competing proprietary systems.
e. Simplicity	Simpler designs, in addition to costing less, are more likely to be repaired properly by field personnel.
7. Aesthetics	Occasionally, barrier aesthetics is an important consideration in selection.
8. Field Experience	The performance and maintenance requirements of existing systems should be monitored to identify problems that could be lessened or eliminated by using a different barrier type.

SELECTION CRITERIA FOR ROADSIDE BARRIERS

Figure 38-5.B

38-6 ROADSIDE BARRIER LAYOUT

38-6.01 Length of Need

A roadside barrier must be extended a sufficient distance upstream and/or downstream from the hazard to safely protect a run-off-the-road vehicle. Otherwise, the vehicle could travel behind the barrier and impact the hazard. The designer should recognize that vehicles depart the road at relatively flat angles. These flat angles of departure result in the need to extend the barrier a significant distance in front of the hazard.

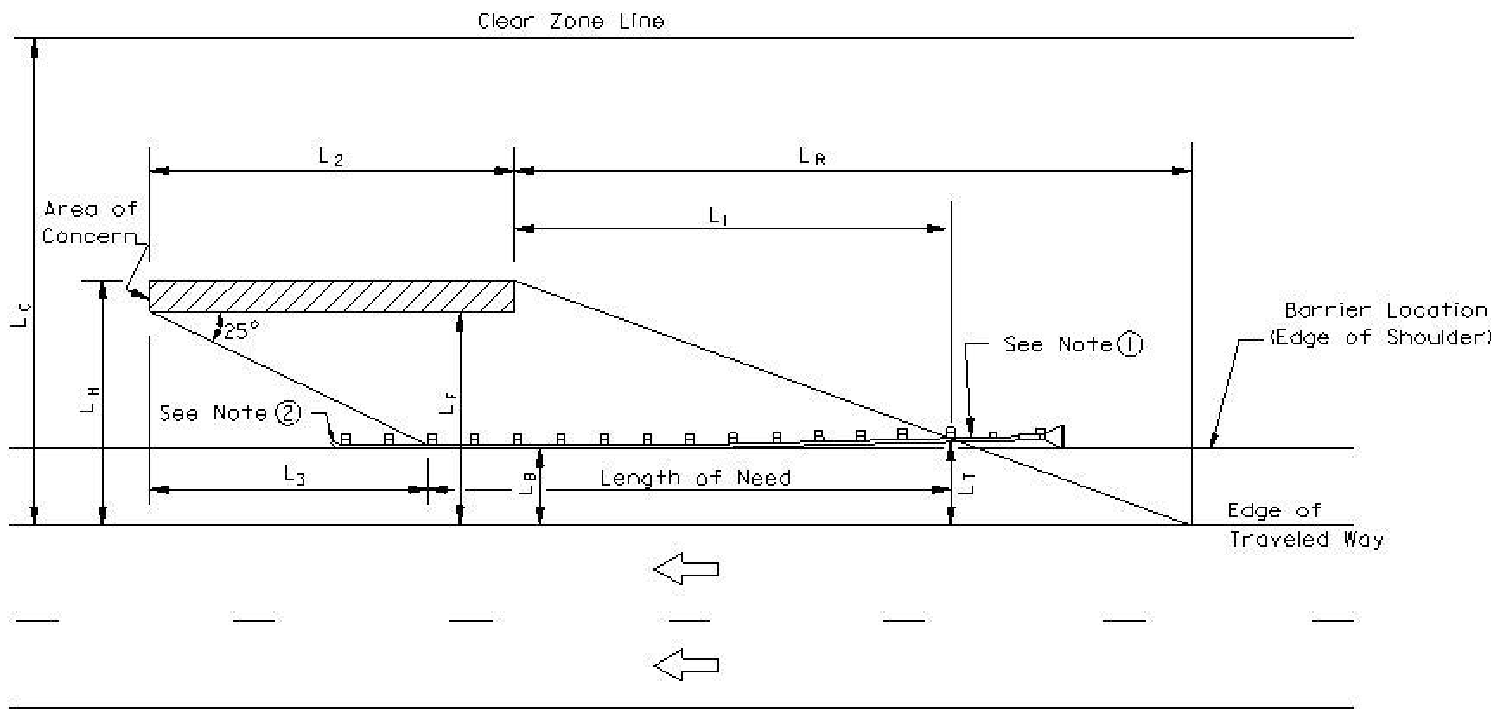
Many factors combine to determine the appropriate length of need for a given roadside condition. These include:

- the distance to the outside limit of the hazard (L_H) or the clear zone (L_C), whichever is less;
- the distance between the edge of traveled way and the barrier (L_B);
- the runout length (L_R), which is based on the design speed (V) and the traffic volume on the facility;
- the length of hazard (L_2), as measured parallel to the roadway;
- whether or not the barrier is on a flare (see Figure 38-6.P); and
- on two-way facilities, whether or not the barrier needs to be extended to provide protection for the traffic in the opposing direction.

Figures 38-6.A and 38-6.B illustrate the variables that will determine the barrier length of need. Figure 38-6.A applies to a one-way roadway or to a two-way roadway where the hazard is not within the clear zone of the opposing traffic. Figure 38-6.B applies to a two-way roadway where the roadside hazard is within the clear zone of the opposing traffic.

For two-way, two-lane roadways, both barrier end terminals need to be crashworthy (e.g. Traffic Barrier Terminal, Type 1 Special). For one-way roadways, typically only the terminal on the approach end of the barrier needs to be crashworthy.

Note the first 12.5 ft (3.81 m) of a Type 1, Special end terminal, and the entire length of a Type 2 end terminal, are not included in the length of need as this portion will not redirect a vehicle. Figures 38-6.A and 38-6.B illustrate this by showing the first 12.5 ft (3.81 m) (i.e. two posts) beyond the length of need triangle.



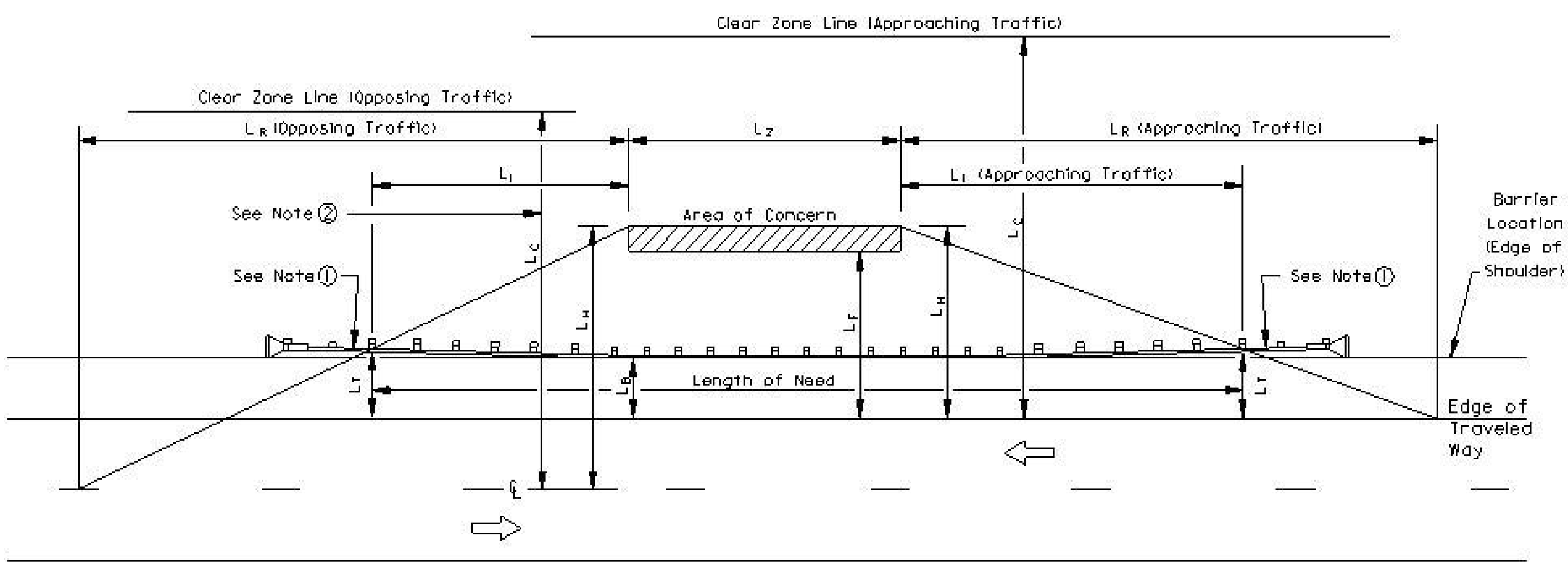
Notes:

① Use appropriate crashworthy terminal. See Section 38-6.06.
② Use acceptable anchorage terminal for one-way traffic or an appropriate crashworthy terminal for two-way traffic. See Section 38-6.06.

L_T = Distance to the barrier at the third post of the terminal
L_B = Distance to the barrier
L_C = Distance to the clear zone
L_H = Distance to the back of the hazard
L_F = Distance to the front of the hazard
L_R = Runout length (see Figure 38-6.E)
L_1 = Length of need for the approach end
L_2 = Length of the hazard
L_3 = Distance from the downstream end of the hazard

BARRIER LENGTH OF NEED LAYOUT
(One-Way Roadways or Two-Way Roadways Where the Hazard is Beyond the Clear Zone of Opposing Traffic)

Figure 38-6.A



Notes:

① Use appropriate crashworthy terminal. See Section 38-6.06.

② If L_c for opposing traffic < (L_F + 12) then refer to Figure 38-6.A.

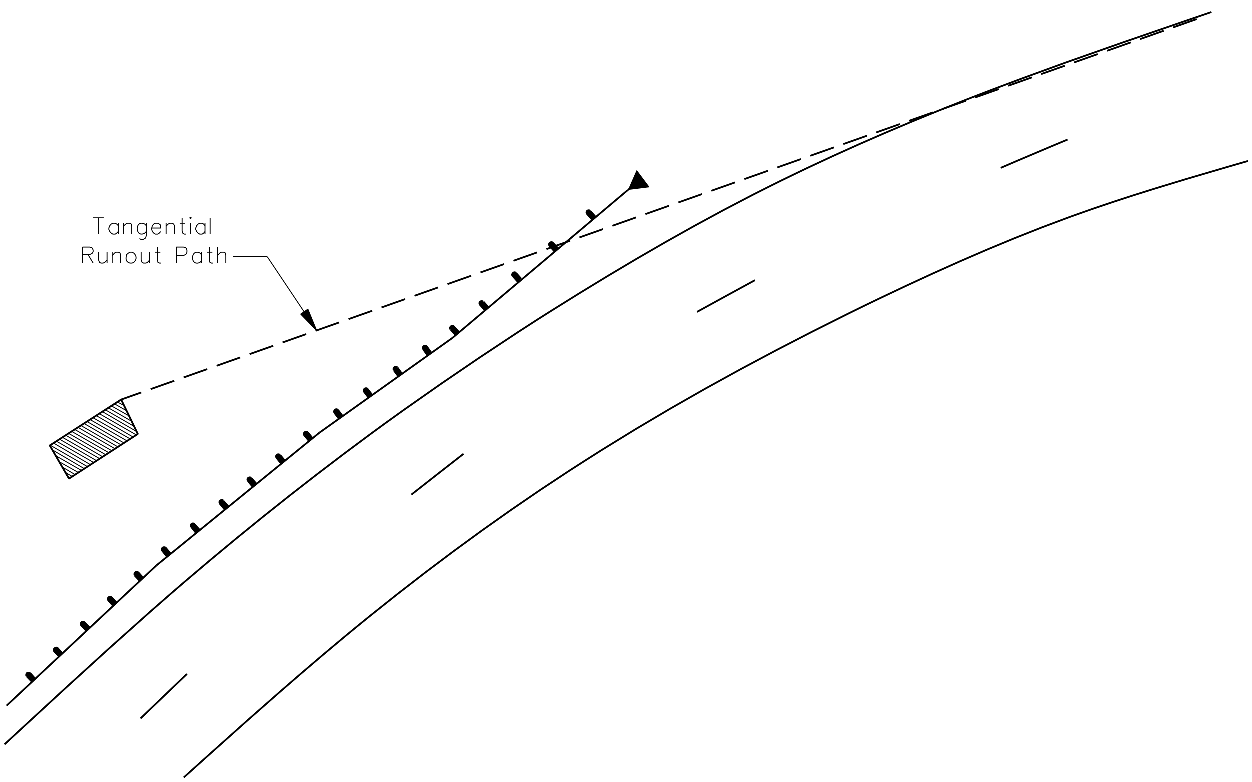
L_T = Distance to the barrier at the third post of the terminal
L_B = Distance to the barrier
L_C = Distance to the clear zone
L_H = Distance to the back of the hazard
L_F = Distance to the front of the hazard
L_R = Runout length (see Figure 38-6.E)
L_1 = Length of need for the approach end
L_2 = Length of the hazard

BARRIER LENGTH OF NEED LAYOUT
(Two-Way Roadways Where the Hazard is Within the Clear Zone of Opposing Traffic)

Figure 38-6.B

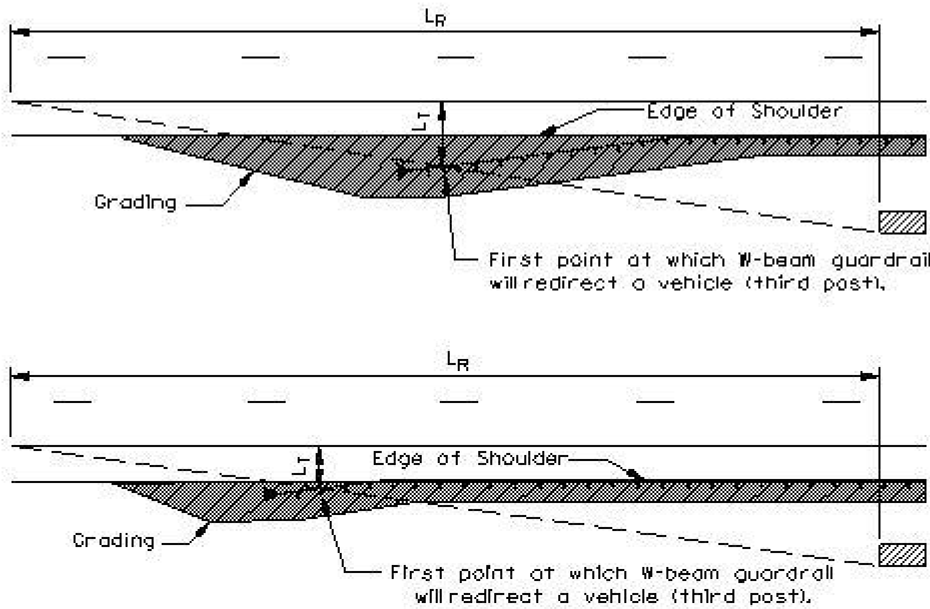
The preferred way to lay out guardrail and determine the length of need is by drawing the installation in plan view using CADD software. Designing graphically offers several advantages:

- Laying out installations along horizontal curves often requires some judgment, and it is helpful to look at the design visually and to-scale; see Figure 38-6.C.
- A graphical layout allows the designer to look at various flare rates and find a good balance between guardrail length and the extent to which the guardrail projects toward the ditch; see Figure 38-6.D. Greater flare rates will shorten guardrail lengths, but may increase the amount of earthwork required for the flat 1V:10H slopes needed in front of the guardrail. Looking at various flare rates visually is a good way to balance these two issues based on site-specific characteristics (e.g., steepness of the foreslope, width of the ditch).
- When designing graphically in plan view, the designer can easily look at contours and cross sections to determine if guardrail should be extended for steep slopes.
- As a quality-control measure, a graphical layout allows the designer to simply look at the design, drawn to scale, and confirm that the design is appropriate.



GRAPHICAL LAYOUT OF GUARDRAIL ALONG A HORIZONTAL CURVE

Figure 38-6.C



GUARDRAIL LENGTH (AMOUNT OF FLARE) VS. AMOUNT OF GRADING

Figure 38-6.D

Using CADD is particularly efficient if cells are developed for the various guardrail components that make up a guardrail installation. Cells can be created for transitions to bridge ends, terminals, standard 12.5 ft (3.81 m) sections, and other components, etc., which can be efficiently placed in CADD to develop layouts and compare designs.

If the installation is on a tangent section of roadway, the nomograph in Figure 38-6.F can be used to determine the length of need. The procedure for using the nomograph is as follows:

1. Draw a horizontal line at L_B on the y-axis (the lateral distance of the barrier from the edge of traveled way). This assumes that the barrier is not flared; i.e., it is parallel to the roadway.

   If a crashworthy terminal is provided, draw the horizontal line at L_T instead of L_B to account for the offset at the third post of the traffic barrier terminal (TBT). Normally this is an additional 2.7 ft (0.8 m) for a TBT Type 1, Special (Flared) and 0.75 ft (0.2 m) for a TBT Type 1, Special (Tangent).

   If the guardrail itself is flared, draw a diagonal line at L_B on the y-axis instead of a horizontal line. The diagonal line must be drawn equal to the flare rate of the guardrail. Example 38-6.01(4) illustrates this scenario.

2. Locate L_H or L_C, whichever is less, on the y-axis.

Design Speed		Traffic Volume (ADT)*							
		Over 10,000		5000-10,000		1000-4999		Under 1000	
		Runout Length L_R		Runout Length L_R		Runout Length L_R		Runout Length L_R	
mph	(km/h)	ft	(m)	ft	(m)	ft	(m)	ft	(m)
70	(110)	360	(110)	330	(101)	290	(88)	250	(76)
60	(100)	300	(91)	250	(76)	210	(64)	200	(61)
55	(90)	265	(81)	220	(67)	185	(57)	175	(54)
50	(80)	230	(70)	190	(58)	160	(49)	150	(46)
45	(70)	195	(60)	160	(49)	135	(42)	125	(38)
40	(60)	160	(49)	130	(40)	110	(34)	100	(30)
30	(50)	110	(34)	90	(27)	80	(24)	70	(21)

**Based on a 10 year projection from the anticipated date of construction*.

RUNOUT LENGTHS (L_R) FOR BARRIER DESIGN

Figure 38-6.E

3. Determine L_R from Figure 38-6.E and locate L_R on the x-axis. If barrier protection is needed for only the approaching traffic, use only the “Edge of Traveled Way Scale.” If needed for both directions of travel, locate L_R on both the “Edge of Traveled Way Scale” and the “Centerline Scale.” See Step 7 to determine the downstream end of the barrier where the hazard does not require shielding for the opposing traffic.

4. Connect the points in Steps 2 and 3 with a straight line(s).

5. Locate the intersection(s) of the lines in Steps 1 and 4. From this point(s), draw a line vertically to the “Edge of Traveled Way Scale and, if required, to the “Centerline Scale” to determine L_1.

6. Read L_1 from the “Edge of Traveled Way Scale” and, if required, from the “Centerline Scale”. As illustrated on Figures 38-6.A and 38-6.B, L_1 is measured from the lateral edge of the hazard to the third post (12.5 ft (3.81 m) from the free end of the terminal), i.e., it does not include the gating portion of the terminal.

7. If barrier protection is only warranted for one direction of travel (Figure 38-6.A), use the following procedure to determine the downstream end of the length of need, otherwise proceed to Step 8:

a. If not done in Step 1, draw a horizontal line from L_B at the y-axis to represent the lateral distance of the barrier from the edge of travel way (i.e., no adjustment for the flare of the terminal).

b. Locate L_F on the y-axis as the distance from the front of the hazard, at the downstream end, to the edge of traveled way.

c. From point L_F, draw a line parallel to the 25° line in Figure 38-6.F until it intersects the L_B line.

d. From the intersection between the L_B line and the L_F line, draw a line vertically to the "Edge of Traveled Way Scale" and read L_3.

8. Calculate the length of need (LON):

   If barrier protection is warranted for only one direction of travel:

   $$LON = L_1 + L_2 - L_3 \qquad \text{Equation 38-6.1}$$

   If barrier protection is warranted for both directions of travel:

   $$LON = L_1 \text{ approach} + L_2 + L_1 \text{ opposing} \qquad \text{Equation 38-6.2}$$

9. Adjust the LON to provide full 12.5 ft (3.81 m) panels of guardrail. This is done by dividing the LON calculated in Step 8 by 12.5 ft (3.81 m), rounding that result up to the next integer, and then multiplying that integer by 12.5 ft (3.81 m).

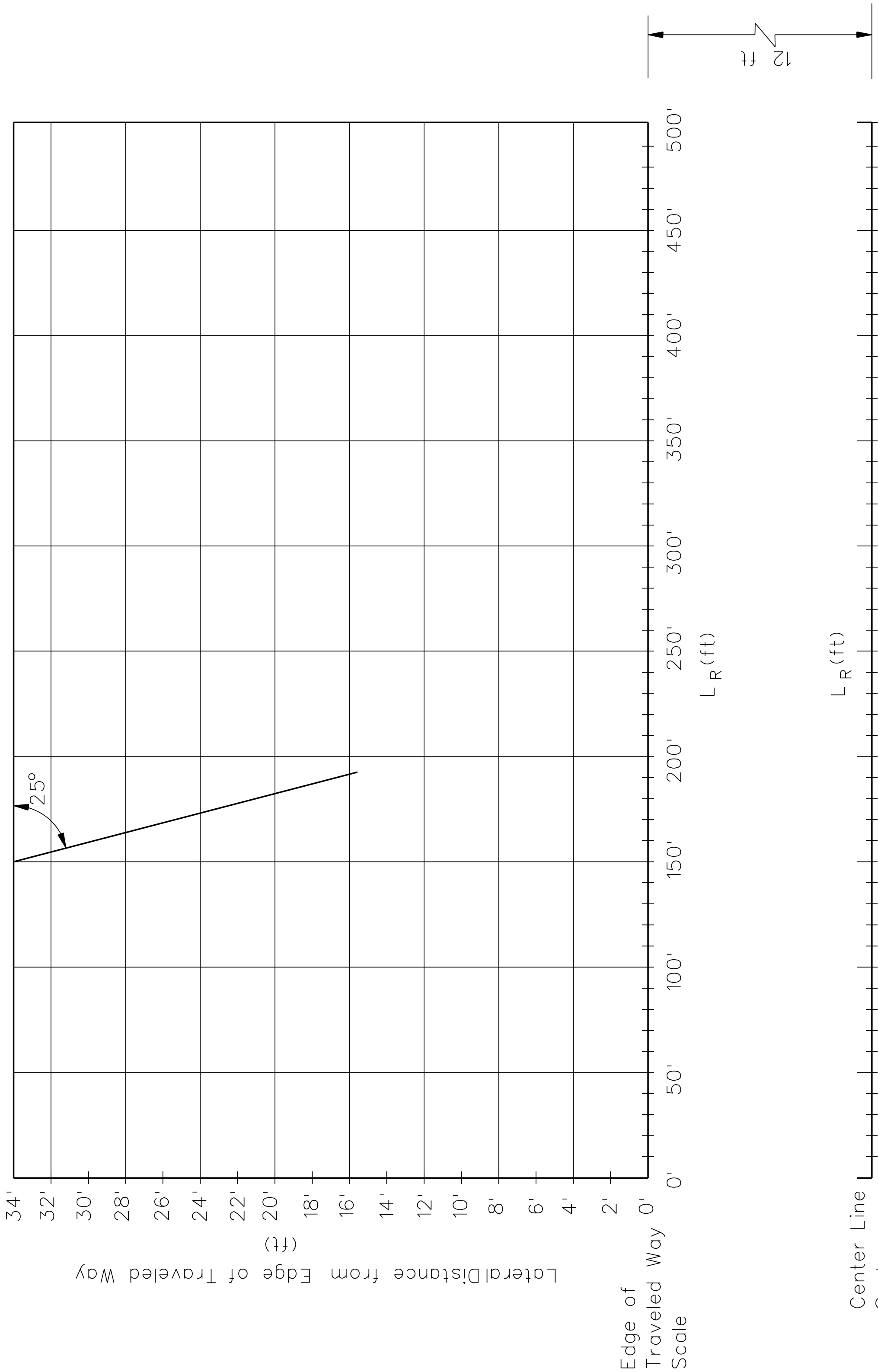
10. Finally, determine the quantity of guardrail to be included in the plans by taking into account: 1) the portion of a TBT that counts toward the LON; and 2) the location of guardrail splices in relation to the pay limit of the TBT. For example:

   - A TBT Type 1, Special provides 37.5 ft (11.43 m) of the LON so that length needs to be subtracted from the LON adjusted in Step 9. However the guardrail splices in a TBT Type 1, Special are offset from the posts and ¼ of a panel (i.e. 3.125 ft (952 mm)) extends beyond the pay limit of the TBT; so that length needs to be added since it will be paid for as guardrail.

   - The entire length of a TBT Type 6, 6A, or 6B counts toward the LON so that length needs to be subtracted from the LON adjusted in Step 9 (see applicable Highway Standard for terminal length). However, the guardrail splices in each of these terminals occur at the posts and therefore nothing needs to be added to the guardrail quantity. Note: Since these terminals have odd lengths, perform Step 9 again after deducting the length to provide full panels of guardrail.

   - A TBT Type 2 provides nothing to the LON and the guardrail splice occurs at the posts; so this type of terminal does not affect the guardrail quantity.

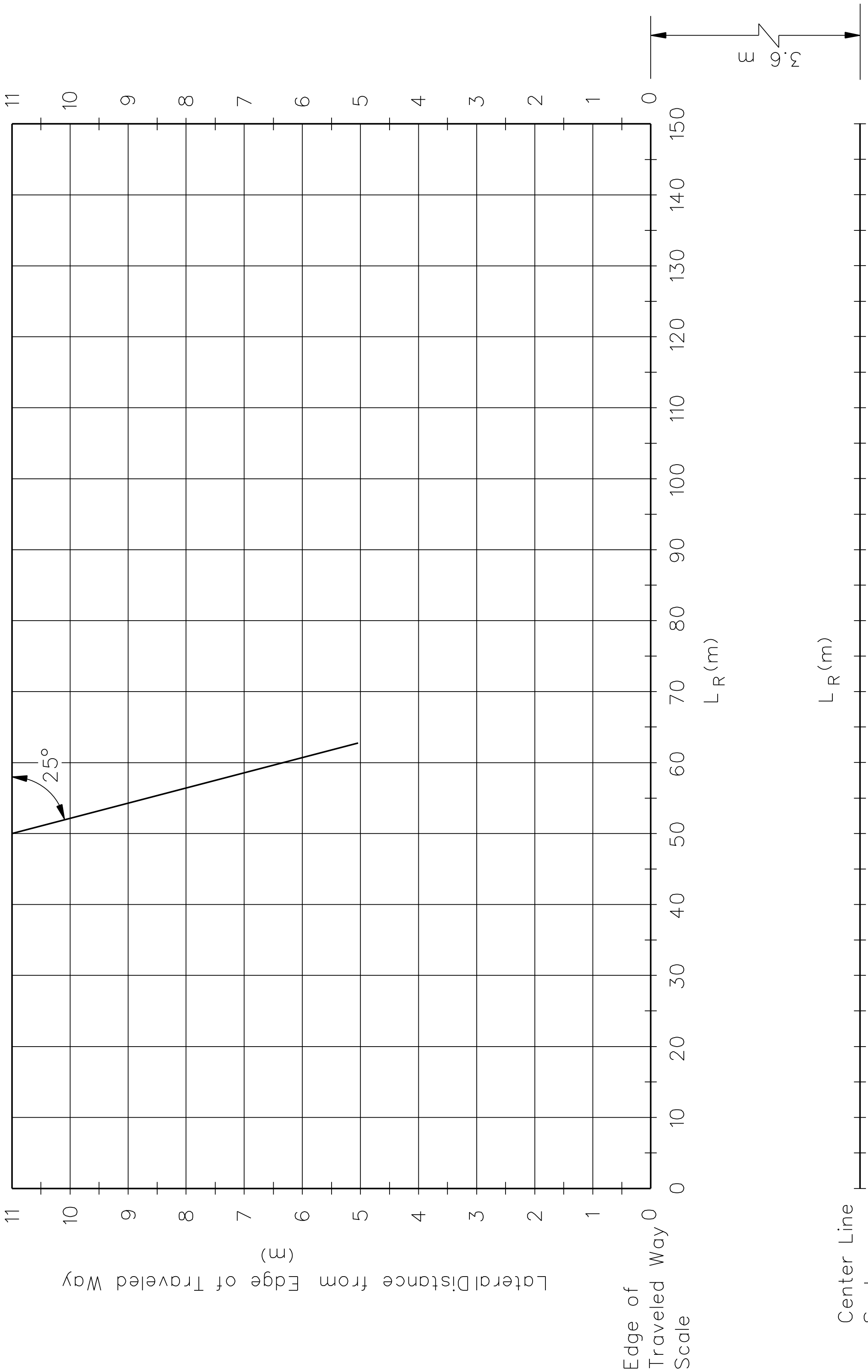
* * * * * * * * *



Note: Centerline scale assumes a 12-ft lane width. For other lane widths, appropriate adjustments must be made.

BARRIER LENGTH OF NEED CALCULATION (TANGENT ROADWAYS ONLY)
(US Customary)

Figure 38-6.F



Note: Centerline scale assumes a 3.6-m lane width. For other lane widths, appropriate adjustments must be made.

BARRIER LENGTH OF NEED CALCULATIONS
(Metric)

Figure 38-6.F

Example 38-6.01(1) (One-Way Traffic)

Given: One-way roadway
Design ADT = 7000
Design speed = 70 mph
Slope = 1V:6H front slope
Tangent roadway
Shoulder width = 10 ft
L_H = 25 ft
L_2 = 40 ft
L_F = 15 ft
Unflared barrier (steel plate beam guardrail, Type A) located at edge of shoulder (L_B = 10 ft).
Type 1, Special (Flared) terminal

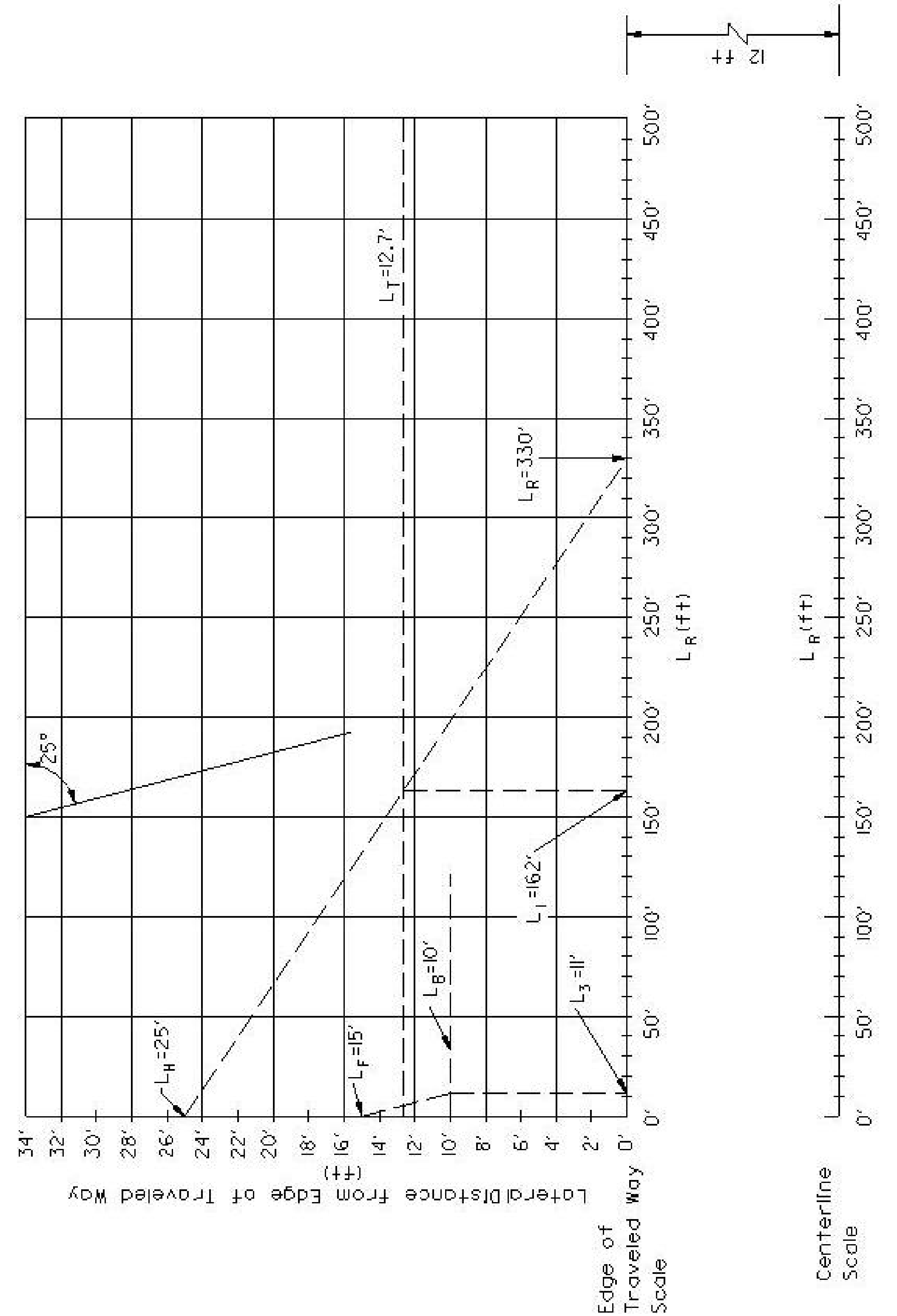
Problem: Determine the barrier length of need and plan length of guardrail, Type A.

Solution: Use the procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.G)

1. Since a Type 1, Special (Flared) terminal is proposed, draw horizontal line, L_T. L_T = 10 + 2.7 = 12.7 ft. The 2.7 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post.
2. From Figure 38-3.A, the clear zone (L_C) is 30 ft and the hazard warrants protection since $L_F < L_C$. Locate the lesser of L_H or L_C, on the y axis. In this case locate L_H = 25 ft on the y-axis.
3. From Figure 38-6.E, L_R = 330 ft. Locate this point on the "Edge of Traveled Way Scale." Since the roadway is one-way, protection is only warranted from one direction, and therefore L_R is not located on the "Centerline Scale."
4. Connect the points in Steps 2 and 3.
5. From the intersection between the lines from Step 1 and Step 4, draw a vertical line down to the "Edge of Traveled Way Scale" to get L_1.
6. Read L_1 = 162 ft from the "Edge of Traveled Way Scale."
7. Since barrier protection is only warranted for one direction, perform the following steps to establish L_3, and thus determine the location of the downstream end of the barrier:
   a. Draw a horizontal line from L_B = 10 on the y-axis.
   b. Locate L_F = 15 ft on the y-axis.
   c. Draw a line from L_F parallel to the 25° line until it intersects the L_B line.
   d. From the intersection between the lines formed from Step 7a and Step 7c, draw a vertical line down to the "Edge of Traveled Way Scale" to find L_3. Read L_3 = 11 ft.

8. Calculate the length of need, LON, of guardrail. In this example barrier protection is needed only in one direction of travel. Therefore:

   LON = 162 + 40 – 11 = 191 Equation 38-6.1



BARRIER LENGTH OF NEED CALCULATION
(Example 38-6.01(1))

Figure 38-6.G

9. Adjust the LON to provide full 12.5 ft panels.

   191/12.5 = 15.28 panels Round up to 16 panels

   16 x 12.5 = 200 ft

10. Determine the plan quantity of guardrail. Since there is one-way traffic, only one TBT Type 1, Special is used. The terminal provides 37.5 ft towards the LON, which is deducted from the adjusted length from Step 9.

    200 – 37.5 = 162.5 ft

    To account for the ¼ panel which extends beyond the TBT, add 3.125 ft to the previous quantity.

    162.5 + 3.125 = 165.625 ft

    The downstream end of the guardrail is a TBT Type 2, which has no affect on the guardrail length so the final length of guardrail for this run is 165.6 ft.

Example 38-6.01(2) (Two-Way Traffic)

Given: Two-lane/two-way roadway
Design ADT = 5000
Design speed = 60 mph
Slope = 1V:4H front slope
Tangent roadway
Shoulder width = 8 ft
L_H = 15 ft
L_2 = 10 ft
L_F = 10 ft
Unflared barrier (use steel plate beam guardrail, Type B, due to deflection constraint) located at edge of shoulder (L_B = 8 ft)
Type 1, Special (Tangent) terminal

Problem: Determine the barrier length of need and plan length of guardrail, Type B.

Solution: Use the procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.H)

1. Since a Type 1, Special (Tangent) terminal is proposed, draw horizontal line L_T. L_T = 8 + 0.75 = 8.75 ft. The 0.75 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post.

2. From Figure 38-3.A, the clear zone (L_C) is 30 ft and the hazard warrants protection for approaching traffic since $L_F < L_C$. Locate the lesser of L_C or L_H on the y-axis. In this case locate L_H = 15 ft on the y-axis for the travel lane closest to the hazard.

   Add 12 ft, the lane width, to L_F to determine if the hazard is within the clear zone for opposing traffic. Since L_F + 12 = 22 ft, and is less than the L_C, guardrail protection is also needed for the opposing traffic.

3. From Figure 38-6.E, L_R = 250 ft. Locate this point on the "Edge of Traveled Way Scale" and the "Center Line Scale", since protection is required for both directions of travel.

4. Connect the points in Steps 2 and 3.

5. From the intersection between the lines from Step 1 and Step 4, draw vertical lines down to the "Edge of Traveled Way Scale" and the "Centerline Scale" to get L_1 for both directions of travel.

6. Read L_1 = 103 ft from the "Edge of Traveled Way Scale" and L_1 = 57 ft from the "Centerline Scale."

7. Skip this step, since protection is warranted from both directions of travel.

8. Calculate the length of need, LON, of guardrail. In this example barrier protection is needed from both directions. Therefore:

   LON = 103 ft + 10 ft + 57 ft = 170 ft Equation 38-6.2

9. Adjust the LON to provide full 12.5 ft panels.

   170/12.5 = 13.6 panels Round up to 14 panels

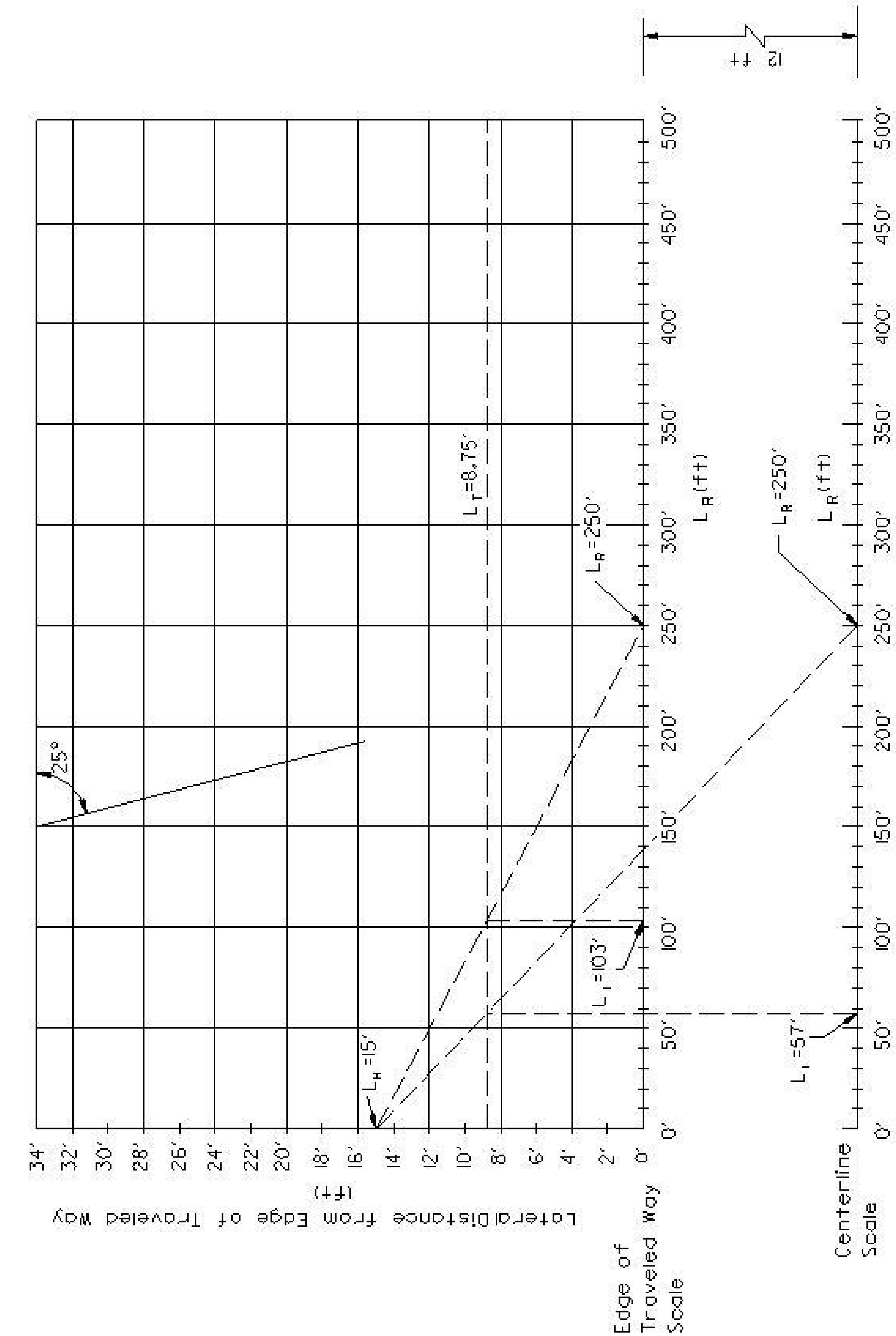
   14 x 12.5 = 175 ft

10. Determine the plan quantity of guardrail. Since there is two-way traffic, two TBT's Type 1, Special are used. Each terminal provides 37.5 ft towards the LON, which is deducted from the adjusted length from Step 9.

    175 – 2(37.5) =100 ft

    To account for the ¼ panel which extends beyond each of the TBT's, add 3.125 ft from each of the TBT's to the previous quantity. This also gives the final length of this guardrail run.

    100 + 2(3.125) = 106.2 ft



BARRIER LENGTH OF NEED CALCULATION
(Example 38-6.01(2))

Figure 38-6.H

Example 38-6.01(3) (Two-Way Traffic — Hazard Beyond Opposing Traffic Clear Zone)

Given: Two-lane/two-way roadway
Design ADT = 5000
Design speed = 60 mph
Slope = 1V:4H front slope
Tangent roadway
Shoulder width = 8 ft
L_H = 23 ft
L_2 = 2 ft (i.e., a point hazard)
L_F = 21 ft
Unflared barrier (steel plate beam guardrail, Type A) located at edge of shoulder (L_B = 10 ft).
Type 1, Special (Tangent) terminal

Problem: Determine the barrier length of need and plan length of guardrail, Type A.

Solution: Use the procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.I).

1. Since a Type 1, Special (Tangent) terminal is proposed, draw horizontal line L_T. L_T = 8 + 0.75 = 8.75 ft. The 0.75 ft is added to the shoulder width to take into account the flare of the guardrail terminal at the third post.

2. From Figure 38-3.A, the clear zone (L_C) is 30 ft and the hazard warrants protection for approaching traffic since $L_F < L_C$. Locate the lesser of L_C or L_H on the y-axis. In this case locate L_H = 23 ft on the y-axis.

   Add 12 ft, the lane width, to L_F to determine if the hazard is within the clear zone for opposing traffic. Since L_F + 12 = 33 ft, and is greater than L_C, guardrail protection may not be required for the opposing direction of traffic. Use engineering judgment or follow the guidance in Section 38-3 to determine the need for roadway protection for the opposing direction of traffic.

   Although, for this example, it is assumed guardrail protection from the point hazard for the opposing direction traffic is not required, a crashworthy terminal is needed downstream because of two-way traffic.

3. From Figure 38-6.E, L_R = 250 ft. Locate this point on "Edge of Traveled Way Scale." Since protection is warranted for approaching traffic only, there is no need to locate L_R on the "Centerline Scale."

4. Connect the points in Steps 2 and 3.

5. From the intersection between the lines from Step 1 and Step 4, draw a vertical line down to the "Edge of Traveled Way Scale" To get L_1.

6. Read L_1 = 153 ft from the "Edge of Traveled Way Scale" for approaching traffic.

7. Since barrier protection is only warranted for one direction, perform the following steps to establish L_3, and thus determine the location of the downstream end of the barrier.

   a. Draw a horizontal line L_B. L_B = 8 ft.
   b. Locate L_F = 21 ft on the y-axis.
   c. Draw a line parallel to the 25° line from L_F until it intersects the L_B line.
   d. From the intersection between the lines formed from Step 7a and 7c, draw a vertical line down to the “Edge of Traveled Way Scale.” Read L_3 = 29 ft.

8. Calculate the length need, LON, of guardrail. In this example barrier protection is needed in one direction of traffic. Therefore:

   LON = 153 + 2 - 29 = 126 ft Equation 38-6.1

9. Adjust the LON to provide full 12.5 ft panels

   126/12.5 = 10.8 Round up to 11 panels

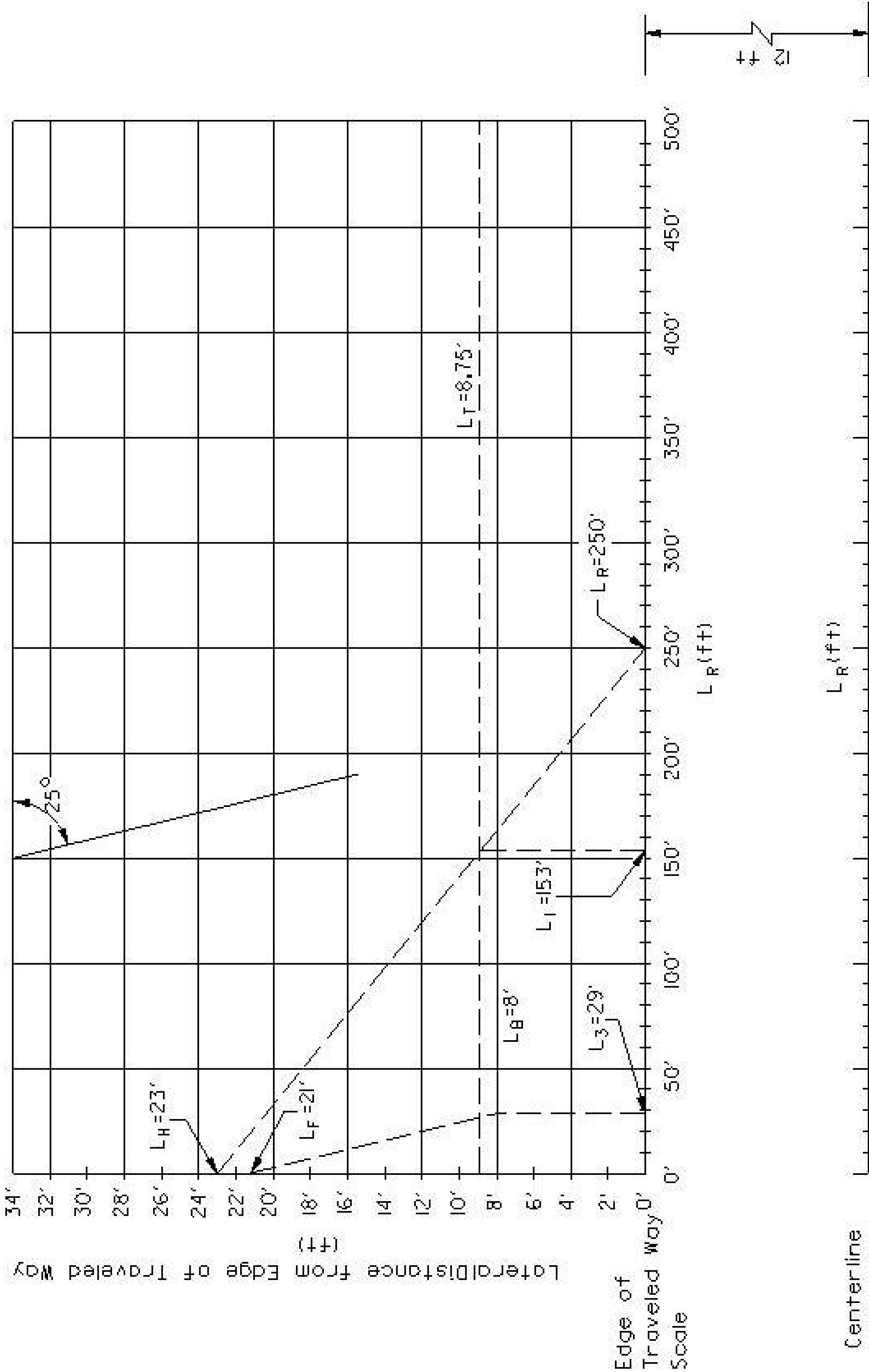
   11 x 12.5 = 137.5 ft

10. Determine the plan quantity of guardrail. Although barrier protection is only needed from one direction, two TBT’s Type 1, Special are used because of the two-way traffic. Each terminal provides 37.5 ft towards the LON, which is deducted from the adjusted length from Step 9.

    137.5 – 2(37.5) = 62.5 ft

    To account for the ¼ panel which extends beyond each of the TBT’s, add 3.125 ft from each of the TBT’s to the previous quantity. This also gives the final length of this guardrail run.

    62.5 + 2(3.125) = 68.8 ft



BARRIER LENGTH OF NEED CALCULATION
(Example 38-6.01(3))

Figure 38-6.I

Example 38-6.01(4) (Flared Barrier)

Given: One-way roadway
Design ADT = 7000
Design speed = 70 mph
Slope = 1V:6H front slope
Tangent roadway
Shoulder width = 10 ft (L_B = 10)
L_H = 25 ft
L_2 = 40ft
L_F = 15 ft
Flared Barrier (steel plate beam guardrail, Type A) with 1:20 flare
Same parameters as Example 38-6.01(1), except the barrier is flared.

Problem: Determine the barrier length of need and plan length of guardrail, Type A.

Solution: Use the procedure starting on page 38-6.5 (refer to the nomograph in Figure 38-6.J)

1. Since the barrier is flared, locate L_B on the y-axis and draw a line from L_B equal to the flare rate 20:1. L_B = 10.

2. From Figure 38-3.A, the clear zone (L_C) is 30 ft and the hazard warrants protection since $L_F < L_C$. Locate the lesser of L_H or L_C on the y-axis. In this case locate L_H = 25 ft on the y-axis.

3. From Figure 38-6.E, L_R = 330 ft. Locate this point on "Edge of Traveled Way Scale." Since the roadway is one-way, protection is only warranted from one direction, and therefore L_R is not located on the "Centerline Scale."

4. Connect the points in Steps 2 and 3.

5. From the intersection between the lines from Step 1 and Step 4, draw a vertical line down to the "Edge of Traveled Way Scale" to get L_1.

6. Read L_1 = 118 ft from the "Edge of Traveled Way Scale."

7. Since barrier protection is only warranted for one direction, perform the following steps to establish L_3, and thus determine the location of the downstream end of the barrier.

   a. Draw a horizontal line from L_B = 10 ft on the y-axis.
   b. Locate L_F = 15 ft on the y-axis.
   c. Draw a line from L_F parallel to the 25° line until it intersects the L_B line.
   d. From the intersection between the lines formed from Step7a and 7c, draw a vertical line down to the "Edge of Traveled Way Scale" to find L_3. Read L_3 = 10 ft.

8. Calculate the length of need, LON, of guardrail. In this example barrier protection is needed in only one direction of travel. Therefore:

   118 + 40 - 10 = 148 ft Equation 38-6.1

9. Adjust the LON to provide full 12.5 ft panels of guardrail.

   148/12.5 = 11.84 Round up to 12 panels

   12 x 12.5 = 150 ft

10. Determine the plan quantity of guardrail. Since there is one-way traffic, only one TBT Type 1, Special is used. The terminal provides 37.5 ft towards the LON, which is deducted from the adjusted length from Step 9.

    150 – 37.5 =112.5 ft

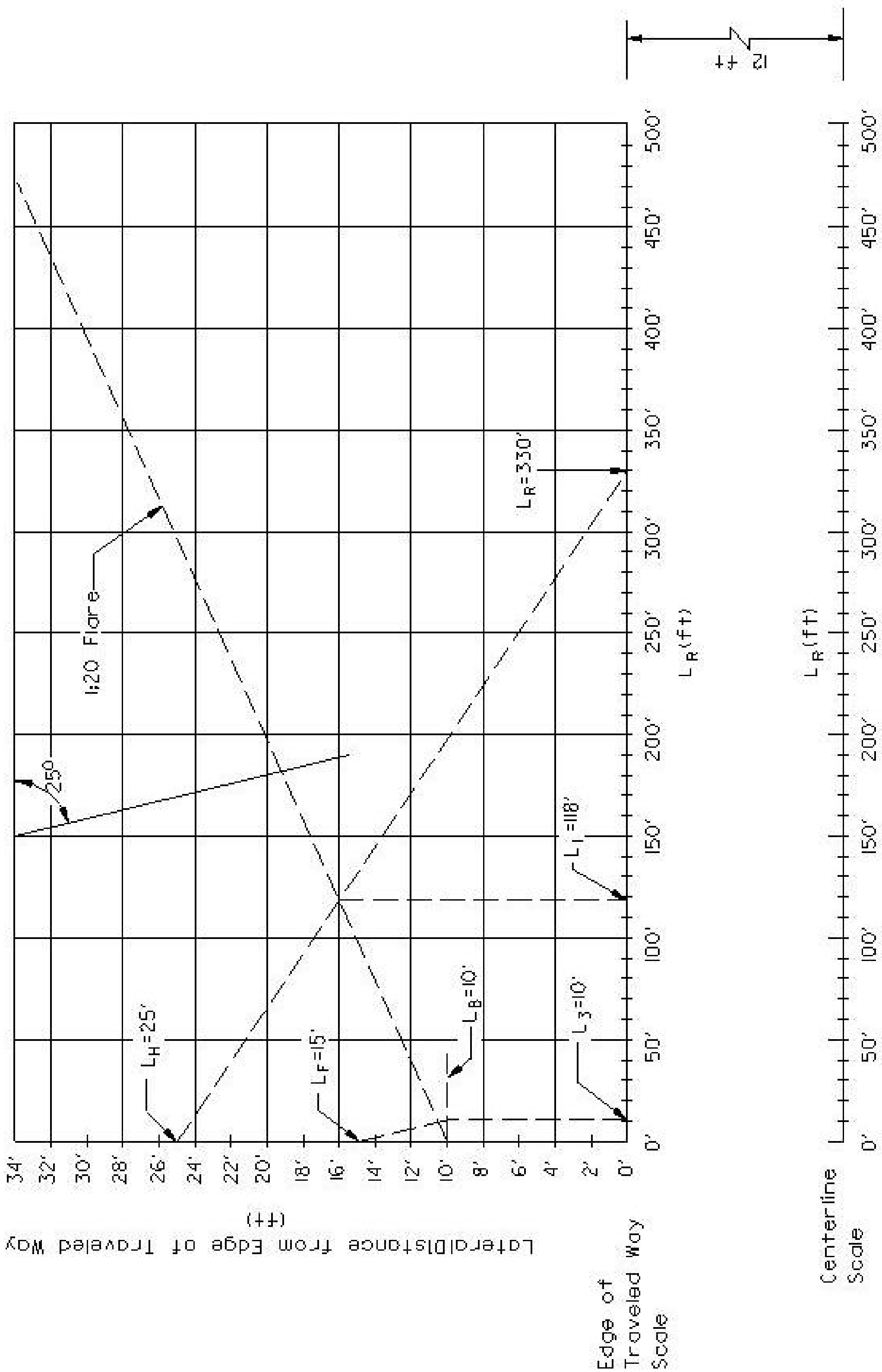
    To account for the ¼ panel which extends past the TBT, add 3.125 ft to previous quantity.

    112.5 + 3.125 = 115.625 feet.

    The downstream end of the guardrail is a TBT Type 2, which has no affect on the guardrail length so the final length of guardrail for this run is 115.6 ft.

    Compare this to the pay quantity of 165.6 feet for the unflared guardrail example used in Example 38-6.01(1).

* * * * * * * * *



BARRIER LENGTH OF NEED CALCULATION
(Example 38-6.01(4))

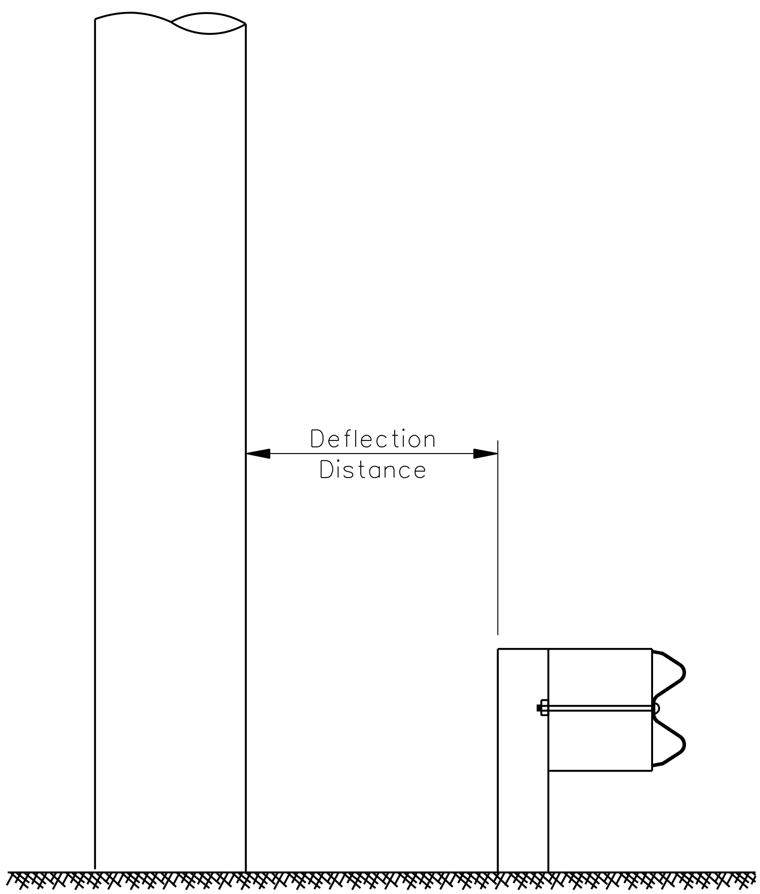
Figure 38-6.J

38-6.02 Lateral Placement

Roadside barriers should be placed as far as practical from the edge of traveled way. Such placement provides an errant motorist the best chance of regaining control of the vehicle without impacting the barrier. It also provides better sight distance, particularly at nearby intersections. The following factors should be considered when determining barrier lateral placement:

1. Shoulder. Typically, the roadside barrier is located at the edge of the shoulder such that the face of the barrier is flush with the edge of shoulder. Include additional grading to provide a hinge point 2 ft (600 mm) behind the back of post.

2. Deflection. Adequate deflection space should be provided so that the barrier can deflect on impact without contacting rigid objects behind the barrier; see Figure 38-6.K. Figure 38-6.L provides the deflection distances for the types of roadside barriers typically used by IDOT.



DEFLECTION DISTANCE FOR W-BEAM GUARDRAIL

Figure 38-6.K

Barrier Type	Deflection Distance
High-Tension Cable Barrier	Allow 12 ft (3.6 m)
Type A W-Beam Guardrail @ 6′-3″ (1905 mm) post spacing	28 in (710 mm)
Type B W-Beam Guardrail @ 3′-1½″ (953 mm) post spacing	23 in (580 mm)
W-Beam Guardrail @ 1′-6¾″ (476 mm) post spacing	14 in (360 mm)
Concrete Barrier	0.0 ft (0.0 mm)

DYNAMIC DEFLECTION OF BARRIERS

Figure 38-6.L

3. Shy Distance. Drivers tend to "shy" away from continuous longitudinal obstacles along the roadside (e.g., guardrail). Therefore, it is desirable that the barrier be offset at or beyond the shy line offsets shown in Figure 38-6.M.

US Customary		Metric	
Design Speed (mph)	Shy Line Offset (ft)	Design Speed (km/h)	Shy Line Offset (m)
70	9.2	120	3.2
65	8.6	110	2.8
60	7.9	100	2.4
55	7.2	90	2.2
50	6.6	80	2.0
45	5.6	70	1.7
40	4.6	60	1.4
35	4.1	50	1.1
30	3.6		

SUGGESTED SHY LINE OFFSET

Figure 38-6.M

4. Steep Slopes. Guardrail post lengths depend on the depth of embedment in the embankment to provide controlled strength and release upon impact. See Highway Standard 630001 for post length requirements.

   Cable barrier may be placed at the breakpoint of 1V:4H slopes. If slopes are steeper, provide the deflection space of the barrier between the back of the system and the break to a slope steeper than 1V:4H.

5. Shoulder Stabilization. Where a barrier is placed on high fills or highly erodible soils, it may be desirable to provide shoulder stabilization in accordance with the *Illinois Highway Standards*. The district geotechnical engineer should be consulted for guidance.

6. Barrier Flare. Flared barrier can substantially reduce the length of need, but usually requires added grading work. See Section 38-6.05.

38-6.03 Placement With Curb

Combining curb and guardrail should be avoided when possible, due to vaulting and other instabilities that can occur when a vehicle simultaneously impacts curb and guardrail. Where it cannot be avoided, consider a sloped curb on high-speed highways to minimize these instabilities. On high-speed highways, a 6 in (150 mm) curb is the maximum allowed.

Type A guardrail has been successfully crash tested to Test Level 3 criteria in conjunction with a standard curb. The face of the guardrail is placed 6 in (150 mm) from the face of the curb as shown in Figure 38-6.N. Use this placement location on all high-speed roadways (speeds greater than 45 mph (70 km/h)), regardless of curb type. Provide a tangent terminal with a 1:50 flare so that the impact head of the terminal does not protrude on the roadway.

On lower-speed roadways, if possible, place the guardrail in the same location. In some situations (e.g., where a sidewalk exists between the roadway and a bridge end), the guardrail may be offset a greater distance behind the curb as illustrated in Figure 38-6.O. A standard curb or sloped curb may be used throughout the installation. Either a tangent or flared terminal may be used.

38-6.04 Placement on Slopes

Slopes in front of a W-beam guardrail should be 1V:10H or flatter. This also applies to the areas in front of the flared section of guardrail and to the area approaching the terminal ends.

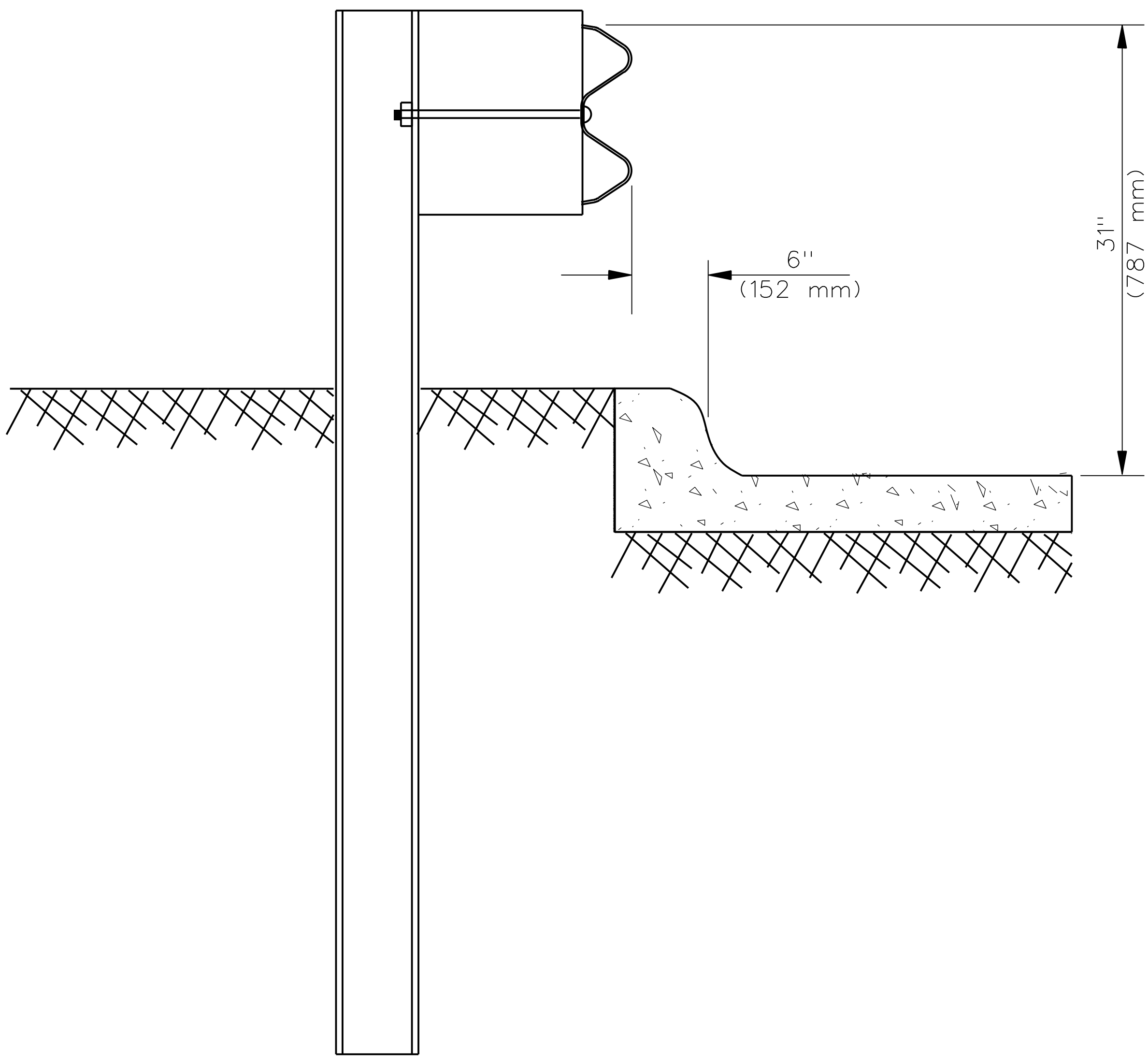
Some high-tension cable barriers may be used on approach slopes of 1V:6H or flatter. See the manufacturer's recommendations.

38-6.05 Barrier Flare

Flaring a roadside barrier away from the roadway has two benefits:

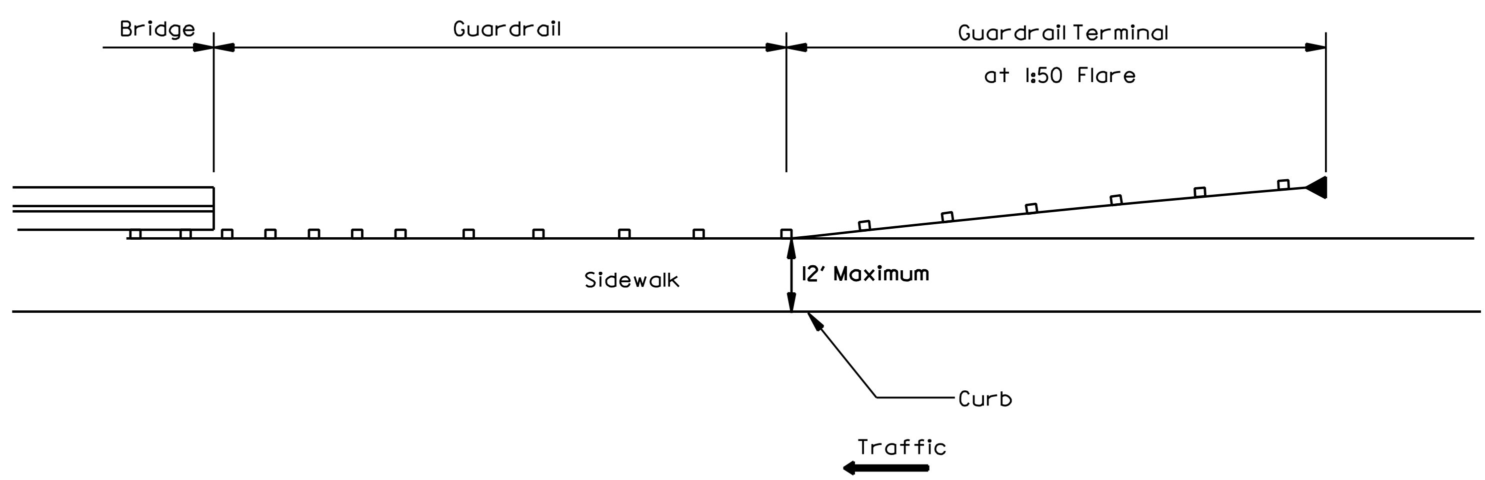
- the length of need is reduced, and
- the barrier is less likely to be impacted.

One disadvantage is that a flare will increase the vehicular angle of impact, although W-beam guardrail has been successfully crash tested with flare rates as high as 1:7. It will also increase the amount of earthwork needed to provide 1V:10H slopes in front of the guardrail and approaching the terminal. When choosing how much to flare guardrail, the designer will need to balance these two issues — the length of guardrail vs. how far the installation projects toward the ditch and the corresponding need for flattening the approach slopes. See Figure 38-6.D.



PLACEMENT OF W-BEAM GUARDRAIL WITH CURB

Figure 38-6.N



W-BEAM GUARDRAIL WITH SIDEWALK AND CURB
(45 mph (70 km/h) or less)

Figure 38-6.O

At the point where tangent guardrail meets flared guardrail, a 12.5 ft (3.81 m) section of guardrail is normally installed on a slight curve by adjusting the posts back a small distance at the transition. This creates a smoother transition and makes the guardrail easier to construct at this point.

Cable barrier for shielding size hazards is normally installed parallel to the roadway, with no flare. In special situations where flare is needed with cable barrier, use a 1:50 flare rate.

Figure 38-6.P presents suggested flare rates for roadside barriers.

Design Speed		**Flare Rate for Barrier Inside Shy Line***	**Flare Rate for Barrier Beyond Shy Line***		
(mph)	**(km/h)**		**Rigid (Concrete)**	**Semi-Rigid (W-Beam)**	**Flexible (Cable)**
70	110 – 120	1:30	1:20	1:7	1:50
60	100	1:26	1:18	1:7	1:50
55	90	1:24	1:16	1:7	1:50
50	80	1:21	1:14	1:7	1:50
45	70	1:18	1:12	1:7	1:50
40	60	1:16	1:10	1:7	1:50
30	50	1:13	1:8	1:7	1:50

**See Figure 38-6.M for shy line distances.*

SUGGESTED FLARE RATES FOR BARRIER DESIGN

Figure 38-6.P

38-6.06 <u>Terminal Treatments</u>

Barrier terminal sections present a potential roadside hazard for run-off-the-road vehicles; however, they are also critical to the proper structural performance of the barrier system. Therefore, the designer must carefully consider the selection and placement of the terminal end.

The *Illinois Highway Standards* present the design details for several end treatments used by the Department. Other proprietary terminal treatments are allowed under various Specifications and Special Provisions. The particular proprietary items routinely allowed for use on IDOT projects are included in the Department's "Approved List for Materials" that is published in the Materials section of the "Doing Business" page of the IDOT internet site. The following sections briefly describe each system and, where applicable, discuss typical uses of the system.

38-6.06(a) Guardrail Ends

The following terminals are applicable to the steel plate beam guardrail:

1. Type 1, Special (Flared). This terminal section is intended for use with steel plate beam guardrail. All approved terminals meet NCHRP Report 350 criteria. The designer should choose a flared terminal where practical, if no additional right-of-way must be purchased for installation and the grading needed to provide a 1V:10H approach slope to the terminal is reasonable. Specifications require that all Type 1 Special (Flared) terminals provide 37.5 ft (11.4 m) length of need. The first 12.5 ft (3.81 m) of the terminal is normally a gating design and not included in the length of need. Because of the gating function, the area behind and beyond the terminal should be traversable and free of fixed objects. The minimum recommended distance is a rectangular area approximately 75 ft (23 m) beyond the terminal parallel to the rail and 20 ft (6 m) behind and perpendicular to the rail.

2. Type 1, Special (Tangent). This is a terminal section intended for use with steel plate beam guardrail. All approved terminals meet NCHRP Report 350 criteria. Tangent terminals should be chosen in areas where the cross section or drainage structure would require additional right-of-way to accommodate the Type 1 Special (Flared) terminal. Specifications require that all Type 1 Special (Tangent) terminals provide 37.5 ft (11.4 m) length of need. Because of the gating function, the area behind and beyond the terminal should be traversable and free of fixed objects. The minimum recommended distance is a rectangular area approximately 75 ft (23 m) beyond the terminal parallel to the rail and 20 ft (6 m) behind and perpendicular to the rail.

3. Type 1B. This terminal should be used at the approaching or departing (where practical) end of roadside barriers where appropriate cut or artificial mound conditions exist or can reasonably be constructed. A 1V:3H or steeper backslope is recommended so that the guardrail can be transitioned into the backslope over a short distance. The guardrail and terminal should also not be tangent to the roadway for this application. Rather, it should flare away and into the backslope or berm.

4. Type 2. This is an unflared terminal with a cable anchor. The Type 2 should be used on the departing end of W-beam guardrail where end-on impacts are not a consideration; i.e., on one-way roadways. The length of this terminal should not be considered as part of the length of need required to shield the hazard.

38-6.06(b) Median Barriers

See Section 38-7.04(d) for guidance on Department-approved end terminals (impact attenuators) for median barriers. These also apply to the ends of the concrete barrier where it is used as a roadside barrier.

38-6.06(c) Bridge Rail Connections

Roadside barriers are often terminated with a transition into a bridge rail. The following terminals are used as bridge rail connections:

1. Type 5. This is a connector terminal which should be used to connect steel plate beam guardrail to the concrete bridge parapet or end post at the departing end of a new one-way bridge.

2. Type 5A. This is a connector terminal that should only be used for repair of existing installations on the State system, and for Local Roads projects, if specified by the Local Agency. It is used to connect steel plate beam guardrail to a steel bridge rail at either the approaching end or departing end of the bridge. For applications on the State highway system, or other locations where compliance with NCHRP Report 350 is required, see Type 6.

3. Type 6. This is a connector terminal that includes a transition section, special posts, blockouts, and end shoe. It also requires the use of a curb. Use Type 6 to attach steel plate beam guardrail to the end(s) of bridges with concrete parapet or to a permanent concrete barrier. It may also be used to connect the steel plate beam guardrail to the face of other concrete structures where the related curb can be installed.

4. Type 6A. This transition is similar to the Type 6, except it is used for attachment of steel plate beam guardrail to either curb-mounted steel bridge rail or to side-mounted steel bridge rail (two element rail systems approved under NCHRP Report 350). When used with a bridge rail system that includes a curb, a curb must be used with the Type 6A, similar to the Type 6. If there is no curb used on the bridge, do not use a curb with the Type 6A.

5. Type 6B. This transition is used when connecting steel plate beam guardrail to the face of a concrete structure (e.g., a pier) and where the installation of a curb is either not possible or desirable. It requires blocking out the thrie beam rail of the transition by 8 in (200 mm) at the connection point. The designer must carefully weigh the relative merits of this potential loss of horizontal clearance against the complications of adding a curb when selecting between the Type 6B terminal and the Type 6 for attachment to a structure.

6. Type 8. This is a connector terminal that includes a transition section, special posts, blockouts, and a turned-down connection to the top of the safety curb. Only use Type 8 to repair existing installations until the bridge cross section can be reconstructed with a bridge railing and guardrail transition system accepted under NCHRP Report 350 and approved by the Department.

7. Type 9. This is a connector terminal to transition from tubular thrie beam retrofit to steel plate beam guardrail. Only use Type 9 to repair existing installations until the bridge cross section can be reconstructed with a bridge railing and guardrail transition system accepted under NCHRP Report 350 and approved by the Department.

8. Type 10. This is a connector terminal that should be used to connect steel plate beam guardrail to the departing end of existing one-way bridges.

9. Type 11. This is a connector terminal that should be used to connect temporary bridge railing to temporary concrete barrier. Specifications for the temporary concrete barrier require that the last segment of barrier be fixed in place by anchor pins. These pins are critical to the performance of this terminal to avoid a potential "pocketing" location for impacting vehicles. This terminal, as shown on Highway Standard 631051, is considered adequate for NCHRP Report 350 Test Level 2; for design speeds up to 45 mph (70 km/hr). Where speeds are higher, the post spacing for the temporary bridge railing shall be no more than 3′-1½″ (953 mm). With the reduced post spacing for the temporary bridge rail, this transition is considered adequate for NCHRP Report 350 Test Level 3.

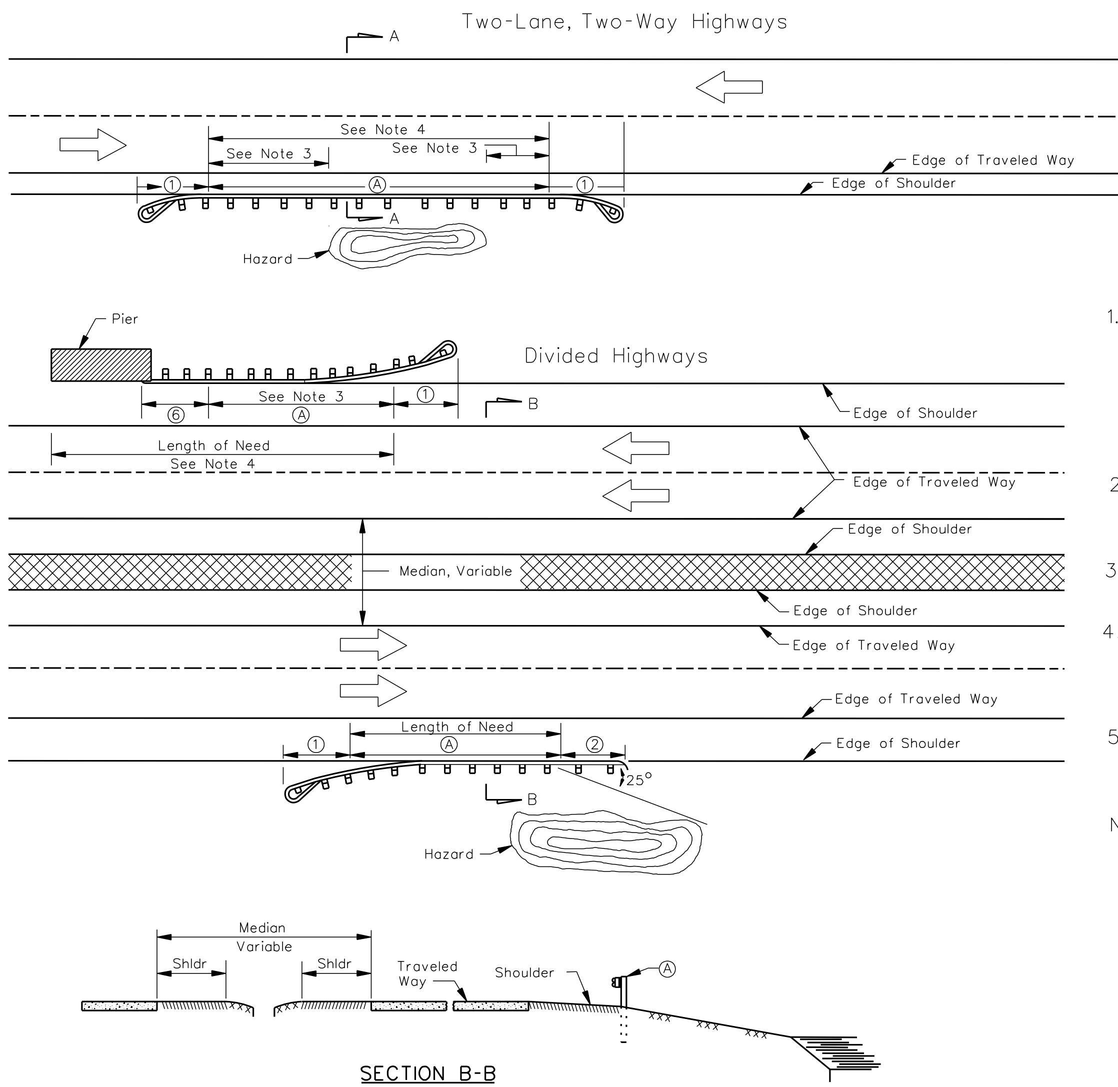
10. Type 12. This is a terminal used to shield the end post(s) of the bridge and to terminate tubular thrie beam on the departing end of one-way bridges that have the tubular thrie beam retrofit for bridges, and when there is not warranting criteria for additional steel plate beam guardrail off the end of the bridge. Because there is no NCHRP Report 350 accepted transition from the tubular thrie beam retrofit rail for the approach end, only use Type 12 to repair existing installations until the bridge cross section can be reconstructed with a bridge railing and guardrail transition system accepted under NCHRP Report 350 and approved by the Department.

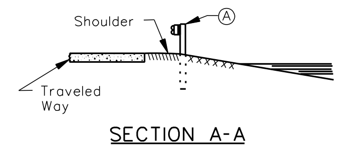
38-6.07 Minimum Length/Gaps

A barrier should have at least 100 ft (30 m) of barrier section exclusive of terminal sections and/or transition sections. The safety performance of shorter installations is unknown. Likewise, short gaps between runs of barrier are undesirable. Therefore, gaps of less than 200 ft (60 m) between barrier termini should be connected into a single run. Exceptions may be necessary for access. Where more than one barrier type is connected with approved transitions, their combined length may be applied to the minimum requirement (e.g., bridge parapet with guardrail transitions, guardrail and terminal(s)).

38-6.08 Typical Applications

Figures 38-6.Q through 38-6.S illustrate typical applications of roadside barrier installations.





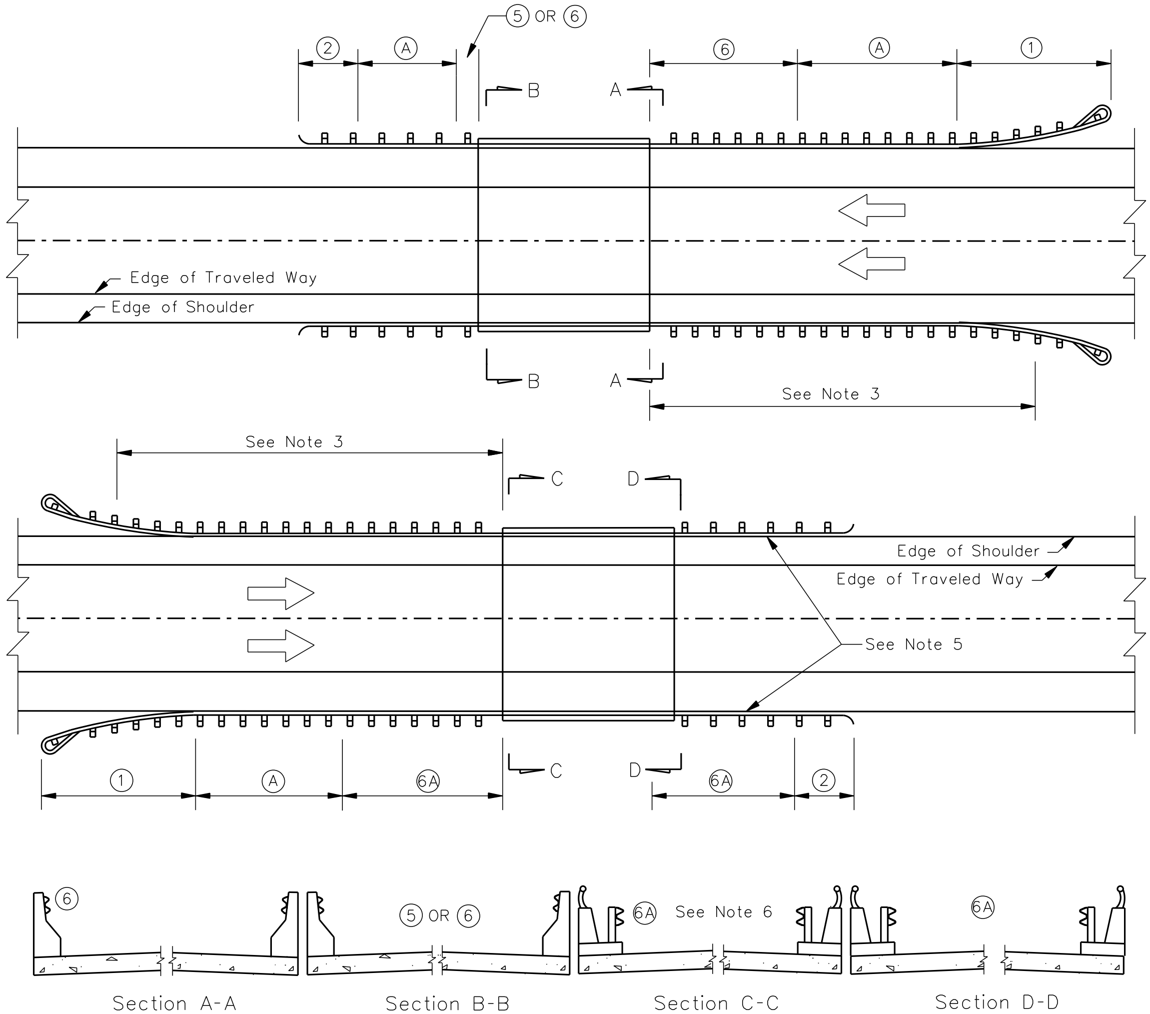
Notes:

1. Traffic Barrier Terminal Types:
   - 1 Type 1, Special
   - 2 Type 2
   - 6 Type 6 (Type 6B may also be considered)
2. Steel Plate Beam Guardrail Types:
   - A Type A (Type B may be used if needed)
3. Length of need in advance of the hazard determined from Figure 38-6.F.
4. Total length of barrier need includes length of need at each end of the hazard plus the length required immediatley adjacent to the hazard. See Section 38-6.01.
5. When Traffic Barrier Terminal Type 1, Special is used, a portion is applied to the length of need.

Not to scale.

TYPICAL APPLICATION OF GUARDRAIL AND TRAFFIC BARRIER TERMINALS

Figure 38-6.Q



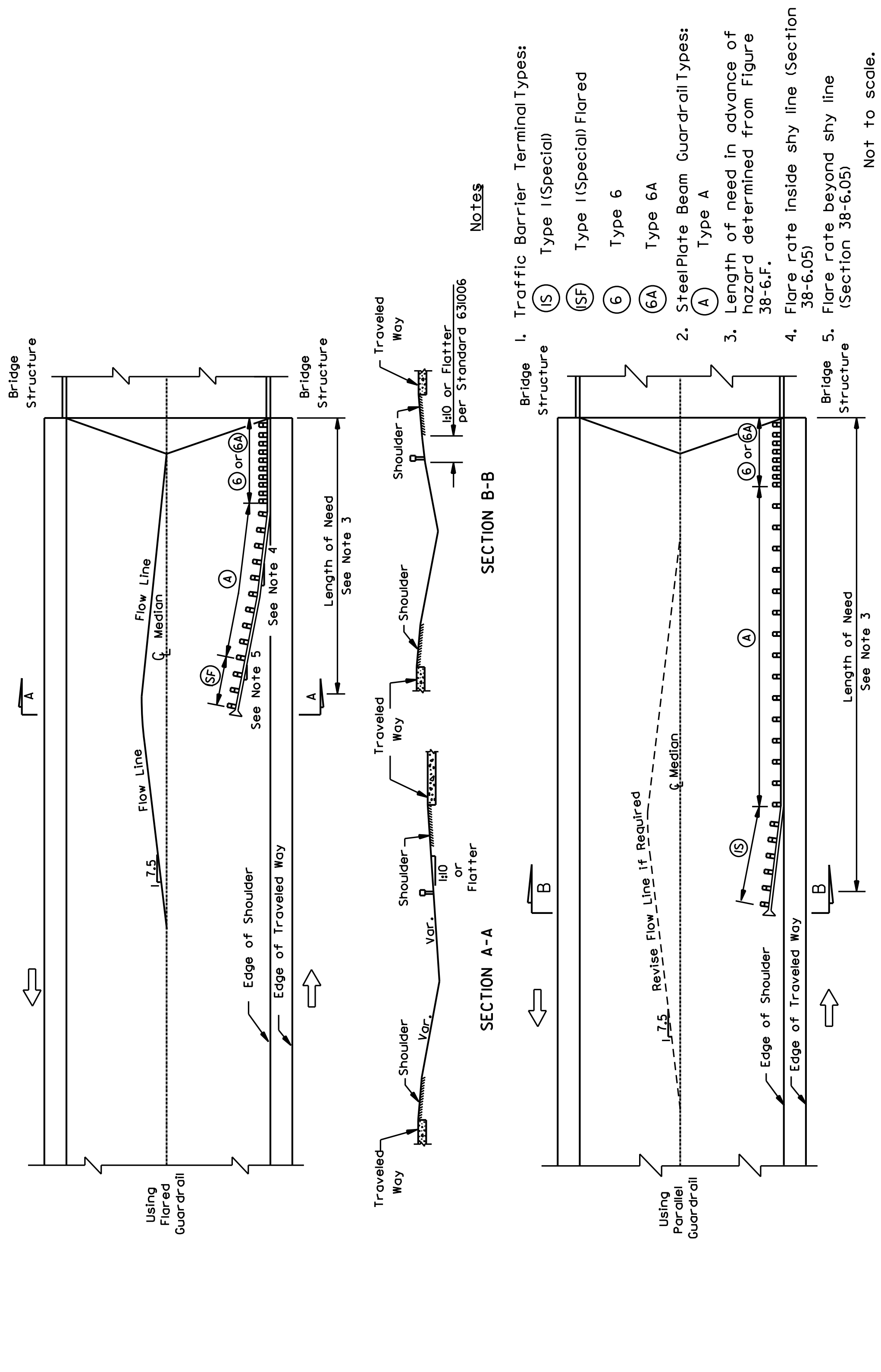
Notes:

1. Traffic Barrier Terminal Types:
   1 Type 1, Special
   2 Type 2
   5 Type 5
   6 Type 6
   6A Type 6A
2. Steel Plate Beam Guardrail Types:
   A Type A
3. Guardrail length of need should be determined from Figure 38-6.F.
4. When Traffic Barrier Terminal Type 1, Special is used, a portion of terminal is applied to the length of need, determined from Figure 38-6D.
5. Guardrail is to be placed at the departing end of one-way bridges only when guardrail is needed for some other uncorrectable hazard. Length of need as per Note 3 above.
6. Safety walk greater than 9 in (225 mm) wide must be removed or retrofitted.

Not to scale.

TYPICAL APPLICATION OF GUARDRAIL AND TRAFFIC BARRIER TERMINALS
(Median Widths Less Than 64 ft (19.5 m) at Dual Structures)

Figure 38-6.R



TYPICAL APPLICATION OF GUARDRAIL AND TRAFFIC BARRIER TERMINALS
(For Median Widths at Dual Structures)

Figure 38-6.S

38-6.09 Short Radius Guardrail

There are currently no short radius guardrail systems accepted under the criteria of NCHRP Report 350 or AASHTO MASH. A side road or entrance within the length of need of a guardrail installation poses a severe challenge to the design of a safe roadside. The most common approach to this situation has been to install a short radius guardrail around one or both of the roadway radius returns. However, a vehicle impacting the radius at a high angle and speed may penetrate the barrier, or vault over the barrier after the posts lean back, creating a ramping effect. Where penetration or vaulting does not occur, the vehicle may be decelerated at an excessive rate.

Recognizing that it is often not practical to change the site conditions by relocating the roadway or entrance to allow for the proper length of need of guardrail, the 2002 edition of the AASHTO *Roadside Design Guide* (RDG) acknowledges that some compromise will be necessary. The RDG recommends that some effort be made to keep errant vehicles from going behind, through, or over the barrier.

38-6.09(a) Preliminary Engineering

During Phase I of a project, see Section 11-2.04(g), the designer evaluates and establishes the roadside barrier warrants. Virtually any decision taken may affect right-of-way needs, earthwork quantities, or other issues and must be recognized early in project development. Decisions to address safety work at a later phase of the project may severely restrict the designer's options. Design exceptions require approval and documentation in the Phase I engineering report.

38-6.09(b) Design Alternatives

1. Relocate or Close the Intersecting Roadway/Entrance. This decision is the preferred solution and should be considered during project scoping, or at least during Phase I preliminary engineering. This decision will involve consideration of expected crash risk, barrier maintenance costs, project scope, cost, and impacts to adjacent properties and the environment. Relocating or closing the roadway or entrance will not always be possible; but, when it is, it will provide the most positive solution to the roadside safety issue. If it is undertaken, give additional consideration to flattening side slopes, widening embankments, etc., to reduce the need for the barrier.

2. Terminate the Guardrail in Advance of the Intersecting Roadway. When relocating or closing the roadway/entrance is not feasible and where the nominal length of need may fall within the intersecting roadway, or just beyond it, the designer may choose to truncate the standard guardrail with an approved terminal section or impact attenuator in advance of the roadway. Flaring the guardrail away from the roadway can be combined with this idea to improve length of need overage. The decision to address the need for guardrail in this manner should be where judgment or analysis indicates this is preferable (flat slopes, minimal drop off) to the additional hazard posed by a short radius guardrail installation.

Termination of guardrail short of the length of need is considered a design exception and must be documented in the Phase I engineering report.

3. Radius Guardrail. If relocating a roadway/entrance or terminating the guardrail short of its length of need cannot be accomplished, the designer may consider a short radius guardrail installation. Any short radius guardrail system will impose constraints on how close it can be installed to a bridge, what radius can be used, and how far it must run along the intersecting side road.

   The RDG recognizes the use of curved guardrails that were crash tested to NCHRP Report 230 criteria, the predecessor to NCHRP Report 350. NCHRP Report 230 represents a past standard, now outdated, especially with regard to pickup trucks, SUVs, and other high center-of-mass vehicles. This old design for short radius guardrail is not compatible with other current standards and should no longer be installed.

   Steel Plate Beam Guardrail, Type A is the only current system usable for a short radius installation. Changes from prior guardrail standards introduce posts more likely to rotate out of a vehicle's path and minimize vaulting, deeper blockouts to minimize snagging, and taller mounting to minimize override. This system has not met any crash testing criteria, but when a short radius guardrail installation is required, it represents an effort to keep a vehicle from behind, over, or through the barrier.

   When terminating the radius guardrail system, the guardrail on the intersecting roadway should be completed to any required length of need and terminated with an appropriate end treatment. On a very low speed roadway (e.g., private driveway), this may be a Type 2 terminal. On most public roadways, or other roadways where higher speeds are possible, provide a Type 1 Special terminal. These terminals are important to provide adequate anchoring of the radius system, and safety for the traffic on the intersecting roadway.

   The decision to use the strong post design (current standard) for a short radius installation is considered a design exception, and must be documented in the Phase I engineering report. The strong post design is the Department's current Standard Type A guardrail installed on the necessary radius. Do not use Type B guardrail in radius applications, as it increases the likelihood that posts will only deflect partially and launch a vehicle. This design may be considered where none of the above alternatives apply or where special studies, site history, etc., indicate it is appropriate.

   Because the strong post radius guardrail system represents some compromise in roadside design, consider an attempt to shadow it from impacts. This can be done by applying a tangent run of guardrail (minimum is 100 feet (30 m) of barrier plus two Type 1 Special Terminals) on the approach side of the intersecting roadway; see RDG. The minimum allowable radius for guardrail is 5 ft (1.5 m) and maximum is 150 ft (45 m).

4. Other Solutions. Other solutions may be possible on a case-by-case basis. For example, in some locations it may be feasible to locate an impact attenuator system in the radius area. Also, combinations of these ideas may be possible, e.g., flaring the

guardrail approaching the short radius, plus providing guardrail on the other side of the entrance to "shadow" the radius installation.

38-7 MEDIAN BARRIERS

Median barriers prevent errant vehicles from crossing the median of a divided highway and colliding with vehicles in the opposing direction of travel. The decision to use a median barrier, as well as the selection of barrier type and height, should be identified in the Phase I engineering report for the project. This decision is especially important for early and accurate coordinate with bridge cross section details.

38-7.01 Median Barrier Warrants

38-7.01(a) Freeways

For freeways with a posted speed of 55 mph or greater, Figure 38-7.A presents the warrants for median barriers based on median width and traffic volumes. Note that the traffic volumes are based on a five-year projection. In the "Study B/C" area of the figure, the decision to use a median barrier should be based on the benefit/cost (B/C) ratio procedure in Section 38-7.01(c). In the "Not Warranted" area of the figure, a median barrier is not normally considered; however, the designer should still look closely at the cross median crash data to determine if a barrier could be cost effective.

38-7.01(b) Highways with a Flush/Depressed Median and Partial Access Control

For highways with both a flush/depressed median and partial access control, the decision to use a median barrier will be based on the (B/C) ratio. As the median barrier must terminate at each at-grade intersection, give special consideration to sight distance and the need to provide a safety treatment at each end of the barrier.

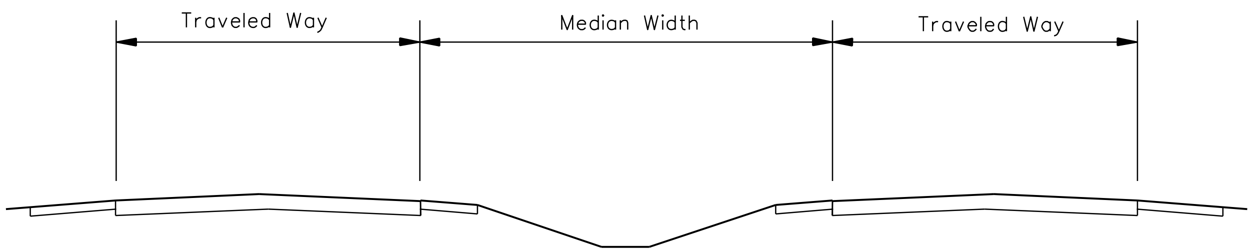
38-7.01(c) Benefit/Cost (B/C) Ratio Procedure

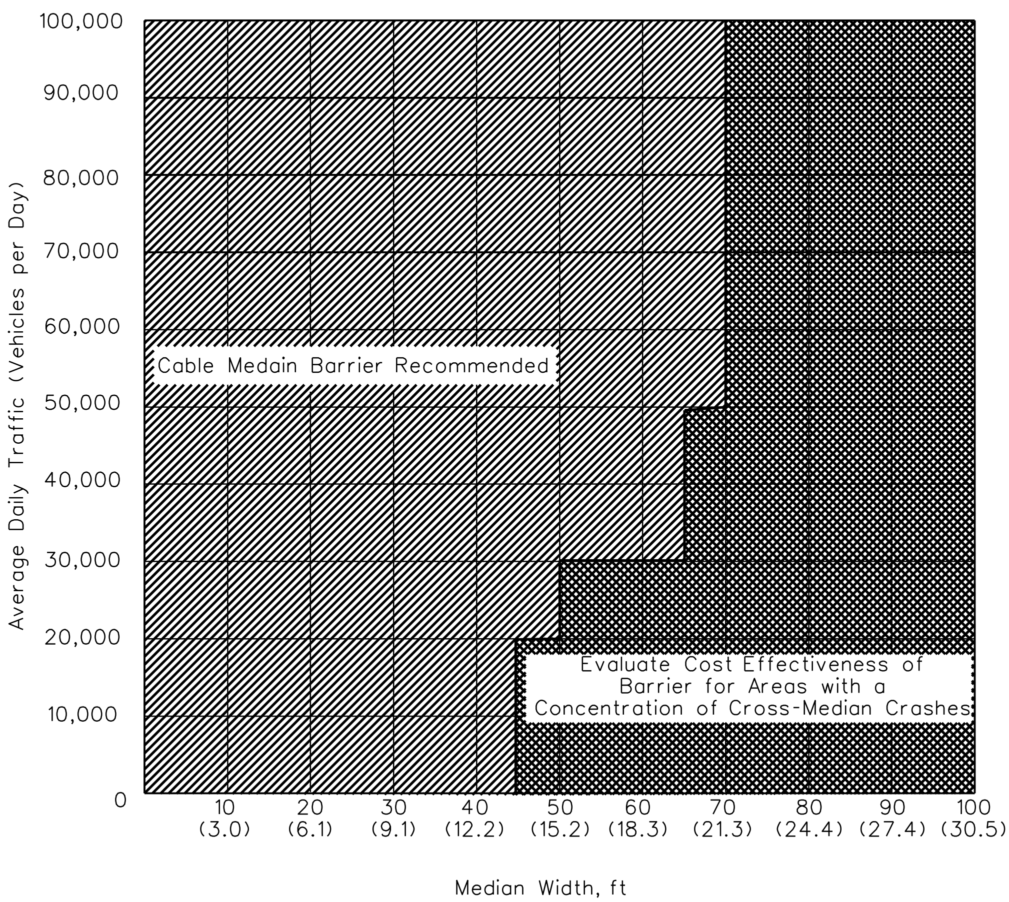
To determine B/C ratio of a median barrier, use the following procedure. This procedure assumes a 15-year life for the median barrier and a 3% discount rate:

1. Determine the Benefit.

    - Determine the annual number of fatal, cross-median crashes. For existing roadways, use an average of at least five years of crash data. For new or reconstructed roadways, contact the Bureau of Safety Engineering regarding how to estimate the number.

    - Determine the annual cost of fatal, cross-median crashes. Multiply the number of fatal cross median crashes (fatal crashes, not fatalities) per year by $1.9 million (2005 dollars). *Note: The designer must either update this dollar figure to the current year using a 3% discount rate or reduce all other costs to 2005 dollars.*





WARRANTS FOR MEDIAN BARRIERS ON FREEWAYS

Figure 38-7.A

- Determine the annual benefit (AB) of installing a median barrier. Multiply the annual cost of fatal, cross-median crashes by 90%.

- Determine the total benefit (b) of the median barrier.

  B = AB x 11.94

  where: 11.94 = present worth factor (for current year)

2. Determine the Cost.

- Select the most appropriate median barrier according to Sections 38-7.02 and 38-7.03.

- Determine the installation cost (IC) of the median barrier. Include in the cost any additional items that are required for the selected barrier (e.g., grading, drainage, paving, mow strips).

- Estimate the number of crashes (encroachments) into the median barrier per year using the Roadside Safety Analysis Program (RSAP).

- Determine the annual repair cost (ARC) of the median barrier. Multiply the estimated number of crashes per year (from the RSAP) by the following:

  + $0 for rigid median barrier,

  + $250 for semi-rigid median barrier, and

  + $500 for flexible median barrier. Documented repair costs in the area may be used in place of these.

- Determine the total cost (C) of the median barrier.

  C = IC + (ARC x 11.94)

  where: 11.94 = present worth factor (for current year)

3. Determine the Benefit/Cost Ratio.

   B/C Ratio = B/C

A minimum B/C ratio of 2.00 warrants installation of a median barrier. When the B/C ratio is between 1.00 and 2.00, other factors should be considered. Other factors include route continuity of median barrier, a progressive and logical "build out" of the barriers, area development trends, future programming for the location, and proximity to interchanges. A study of Illinois' fatal, cross-median crashes has shown that almost 70% happen within one mile (1.6 km/h) of an interchange.

38-7.02 Median Barrier Types

As with roadside barriers, median barriers can be categorized as rigid, semi-rigid, and flexible.

38-7.02(a) Rigid Median Barriers

The rigid median barrier used by the Department is a concrete barrier with the F shape. The 32 in (815 mm) tall concrete barrier is a NCHRP Report 350 Test Level 4 design. The 42 in (1065 mm) tall concrete barrier is an NCHRP Report 350 Test Level 5 design.

While a double-faced barrier is normally used in the median, single-faced concrete barrier may be used to go around a fixed object in the median (e.g., bridge piers) or where twin separated structures are encountered. Single-faced barriers must be designed on a case-by-case basis, are normally reinforced, and are normally tied to the supporting pavement/shoulder.

38-7.02(b) Semi-Rigid Median Barriers

The semi-rigid median barrier used by the Department is steel plate beam guardrail, Type D (double rail). This median barrier meets NCHRP Report 350 Test Level 3 design and is most applicable to medians with intermediate width of 20 ft to 30 ft (6 m to 9 m) and/or moderate traffic volumes (< 5000 MU per day). Another application is for the separation of adjacent on/off ramps at interchanges.

38-7.02(c) Flexible Median Barriers

The flexible median barriers used by the Department are high-tension cable (HTC) median barriers. HTC median barriers consist of cables under high tension, suspended on lightweight posts, with an anchorage foundation at each end to hold the tension on the cables. Currently, each HTC median barrier is proprietary.

The tension present in the cables of an HTC system will allow the cable to remain at effective height after the removal of several supporting posts. This is valuable after a moderate crash, as some level of protection remains until repairs can be completed. However, the weak post component of these systems usually results in some damage, even from minor or nuisance hits. The repair of the weak posts is straightforward, and with socketed systems may not require any specialized equipment.

The HTC median barriers approved for use on slopes of 1V:6H or flatter meet NCHRP Report 350 Test Level 4 design. The barriers approved for use on slopes steeper than 1V:6H, but not steeper than 1V:4H, meet NCHRP Report 350 Test Level 3 design. The terminals for HTC median barriers meet NCHRP Report 350 Test Level 3 design.

38-7.03 Median Barrier Selection

38-7.03(a) Selection Guidelines

The selection of a median barrier type starts with the median width and slopes. These two median conditions will have the greatest impact on the barrier's performance. Figure 38-7.B provides selection guidelines based upon these conditions and also provides the recommended placement for that barrier within the median.

Where more than one type of median barrier is recommended, consider the following factors:

1. Traffic Volumes. Higher traffic volumes generate more impacts on a median barrier. Also, closing lanes to work on median barriers causes more traffic complications where traffic volumes are high. In high-traffic volume locations, rigid barriers are generally preferred because they usually provide continuous, crashworthy service without generating maintenance and repair.

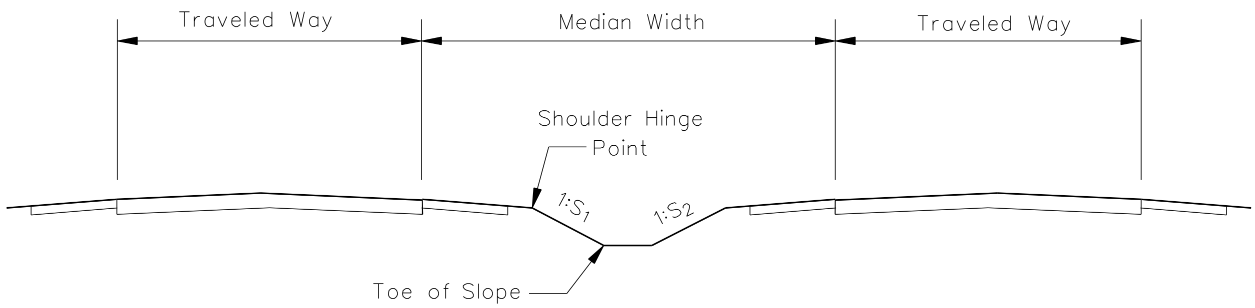
   As a guide, a rigid barrier is likely to be more cost-effective where the peak hour level of service is LOS C or worse and the distance to the median barrier from the traveled way is 12 ft (3.6 m) or less.

2. Heavy Vehicle Traffic. Where there is a high volume of heavy vehicles, or a history of heavy vehicle, cross-median crashes, a rigid barrier would be preferred as it is more likely to contain and redirect heavy vehicles. Maintenance and repairs are not usually required after a hit.

3. Median Appurtenances. A roadway with a median barrier may also warrant other appurtenances in the median (e.g., highway lighting, signs, glare screens). This favors the use of the concrete barrier, which can more readily accommodate these appurtenances.

4. Maintenance Operations. Two factors are important:

   a. First, maintenance response time will influence safety. The longer a damaged section of median barrier is present, the greater the likelihood of a second impact with a damaged barrier. A damaged semi-rigid barrier itself becomes a hazard, close to traffic and remaining, until it is fully repaired and operational. This consideration favors the use of a rigid barrier which normally sustains little or no damage when impacted; however, a flexible median barrier will remain at operational height after some impacts and may still provide protection in the event of a second impact.



Median Conditions		Recommended Median Barrier Type	Recommended Placement
Width	**Slopes**		
W < 25 ft (7.6 m)	S_1 and S_2 ≥ 10	Rigid or Semi-Rigid	Near center of median
	S_1 or S_2 < 10 and S_1 and S_2 ≥ 8	Semi-Rigid	Near center of median
	S_1 or S_2 < 8	N/A – Consider a roadside barrier along each shoulder.	
W ≥ 25 ft (7.6 m)	S_1 and S_2 ≥ 10	Rigid, Semi-Rigid, or Flexible	Near center of median
	S_1 or S_2 < 10 and S_1 and S_2 ≥ 8	Semi-Rigid or Flexible	Near center of median
	S_1 or S_2 < 8 and S_1 and S_2 ≥ 6	Flexible	2 ft (600 mm) or more from shoulder hinge point and more than 8 ft (2.4 m) from the ditch line bottom
	S_1 or S_2 < 6 and S_1 and S_2 ≥ 4	Flexible	Within 4 ft (1.2 m) of shoulder hinge point and more than 10 ft (3 m) from the ditch line bottom
	S_1 or S_2 < 4	N/A – Consider a roadside barrier along each shoulder.	
Other median conditions (e.g., stepped, bermed)		Contact the Bureau of Safety Engineering.	

GUIDELINES FOR MEDIAN BARRIER SELECTION/PLACEMENT

Figure 38-7.B

b. Second, the maintenance operations for repairing a median barrier can be disruptive to traffic. It is important to consider worker safety and traffic safety when developing a traffic control scheme for barrier repair. Lane closures may be necessary where working room is limited. This consideration favors the use of a rigid barrier in narrow medians and/or high-traffic volume areas or a flexible barrier where sufficient space is available adjacent to or behind the barrier to accommodate the smaller equipment needed to repair it.

5. Benefit/Cost Ratio. The barrier type that provides the highest B/C ratio and provides the highest level of safety should be selected.

Figure 38-7.C compares the advantages and disadvantages of the different types of median barriers used by the Department and their typical usage.

Median barriers may also be used in locations other than medians. This would typically occur where a barrier is needed to separate lanes of traffic moving in the same direction, or beginning to diverge.

38-7.03(b) Design Considerations

Each type of median barrier involves elements in their design that must be considered in the selection process. Consider the following:

1. Rigid Median Barriers. When selecting a rigid barrier, the proper height of the barrier must also be selected:

    a. 32 in (815 mm) Height. The 32 in (815 mm) tall concrete barrier should be selected when one or more of the following are met:

        - The roadway has full-access control and the multiple unit (MU) component of the ADT is < 5000 (Test Level 4 is appropriate).

        - The roadway has partial-access control. Sight distance for turning movements is the primary concern.

        - The barrier is being used to separate traffic lanes moving in the same direction (e.g., merging ramps). A sight distance is the primary concern.

    b. 42 in (1065 mm) Height. The 42 in (1065 mm) tall concrete barrier should be selected when one or more of the following are met:

        - The roadway has full-access control and the multiple unit (MU) component of the ADT is ≥ 5000 (Test Level 5 is appropriate).

        - There is a history of median crossover crashes involving large trucks.

Type	Advantages	Disadvantages	Typical Usage
Rigid	1. Can accommodate most vehicular impacts without penetration, especially the 42 in (1065 mm) concrete barrier. 2. Little or no deflection distance required or behind the barrier. 3. Little or no damage sustained for most vehicular impacts; therefore, least need for maintenance. 4. Minimum potential for vehicle underride/ override or snags. 5. Light supports, sign supports, glare screens, etc., may be mounted on top.	1. Highest initial cost. 2. Can induce vehicular rollover. 3. For some conditions, it has highest occupant decelerations (i.e., it is the least forgiving barrier type). 4. Reduced performance where offset between the barrier and the traveled way exceeds 12 ft (3.6 m). 5. Snow drifting.	1. Urban freeways. 2. For high traffic volumes. 3. For high volumes of heavy vehicles. 4. Where maintenance of a median barrier would result in lane closures with significant impacts to traffic. 5. Works well for all median widths, especially moderate to narrow medians.
Semi-Rigid	1. Lower initial cost. 2. High level of familiarity by maintenance personnel. 3. Can safely accommodate wide range of impact conditions for passenger vehicles. 4. Relatively easy installation.	1. Performance for vehicles above 4400 lbs (2000 kg) (PU) is not assured. 2. At high-impact locations, will require frequent maintenance. 3. Snow drifting. 4. Hazard until repaired.	1. Moderate median widths, 25 ft to 40 ft (7.6 m to 12.2 m). 2. Low to mid-range of traffic volumes.
Flexible	1. Lowest initial cost. 2. Can be installed in medians where slopes are as steep as 1V:4H. 3. Repairs usually do not require specialized or heavy equipment. 4. Repairs can be quick. 5. Minimizes snow drifting. 6. Can safely accommodate wide range of impact conditions for passenger vehicles and, on 1V:6H or flatter slopes, single-unit trucks. 7. Remains at height and provides some protection after moderate hits.	1. Performance for heavy vehicles (above 18000 pounds (8000 kg) (SU) is not assured. 2. Virtually every impact will require some repair. 3. Learning curve for maintenance forces when introduced to a new area. 4. Deflection space required behind the barrier: 12 ft (3.6 m) desirable, 9 ft (2.7 m) minimum	1. Medians wider than 25 ft (7.6 m). 2. For low to moderate traffic volumes where repairs can be made without significant traffic impacts.

COMPARISON OF MEDIAN BARRIER TYPES

Figure 38-7.C

- Lighting or other appurtenances will be installed atop the concrete barrier. The taller barrier will reduce the chance of larger vehicles impacting the appurtenances.

- Sharp curves that do not meet current criteria for the roadway's design speed are present.

- The use of the taller barrier will provide design continuity within the corridor.

- A special need exists (e.g., keeping errant vehicles out of mass transit facilities located in a median) or other critical areas where errant vehicles would have catastrophic consequences.

When the 42 in (1065 mm) concrete barrier is selected, it should be applied consistently throughout the section and/or corridor. Only where the 32 in (815 mm) barrier can be used on a continuous basis should the height revert to this lower level.

The selection of a rigid barrier for the median does not imply it will be the appropriate choice for a roadside barrier along the outside shoulders. Generally, steel plate beam guardrail will be the barrier of choice for outside shoulders. The steel plate beam guardrail works well with the conventional 34 in (860 mm) bridge parapet. The use of a rigid barrier along the outside shoulders will be determined on a case-by-case basis.

2. Semi-Rigid Median Barriers. See Section 38-6 as it applies to Type D guardrail.

3. Flexible Median Barriers.

   a. Line Post Foundations. The line posts of HTC median barriers may be driven directly into the ground or may be set into socket-type concrete foundations. Consider the depth of frost penetration. As a rule of thumb, the foundations should be at least 30 in (760 mm) deep south of Springfield, 36 in (915 m) deep from north of Springfield to the south edge of Will County, and 42 in (1.065 m) deep farther north.

   b. End Anchorages. HTC median barriers use significant anchorages (foundations) at each end of a run of cables to hold the high tension. The HTC specifications set out design requirements and require shop drawings from the contractor for the end anchorages.

   c. Mow Strips. Mow strips provide a paved area under and immediately adjacent to the barrier. They are provided as a maintenance consideration to ease mowing and minimize nuisance hits. A typical design is a 4 ft (1.2 m) wide, 4 in (100 mm) thick mat of hot-mix asphalt. If within the shoulder limits, mow strips need to conform to the shoulder slope. Beyond the shoulder limits, mow strips need to conform to the front slope. Avoid drop-offs along the edge of a mow strip. Provide grading, if necessary, to smoothly match the mow strips to the slopes.

d. Length of Need. The length of an HTC median barrier that can be used to satisfy the length of need (see Section 38-6.01) will vary among the manufacturers. Because the brand of HTC will not be known during the design, define the length of need point for all types as 50 ft (15.2 m) from the end of the terminal section.

e. Deflection. Flexible median barriers will deflect more than the other median barrier types. When laying out a flexible barrier, it is desirable that 12 ft (3.6 m) of deflection should be accounted for where the barrier passes fixed objects. At a minimum, allow 9 ft (2.7 m) of deflection.

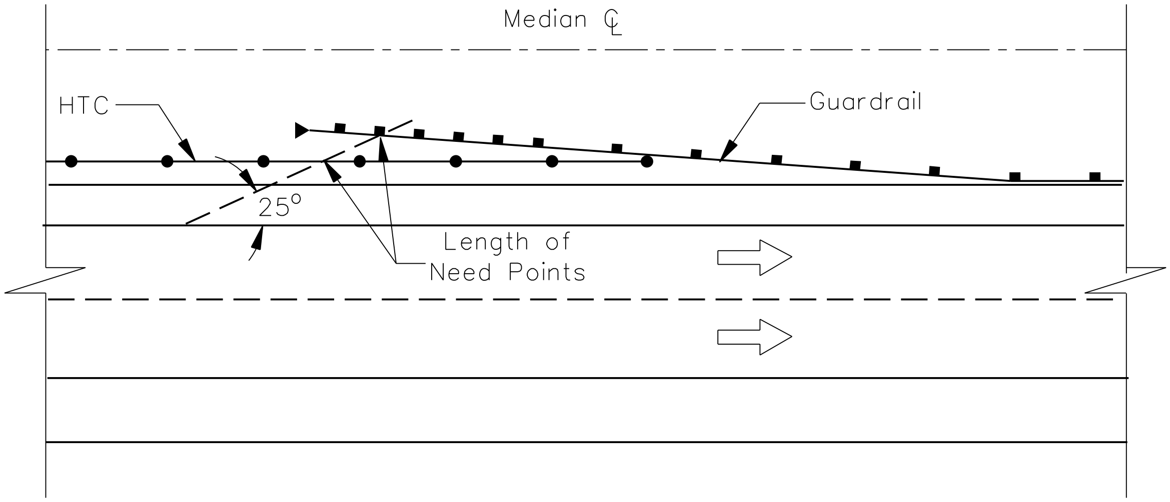
Locate flexible median barriers so that an impacting vehicle will not be allowed to encroach into the traveled way beyond the barrier. However, in some applications, the deflection distance of a median barrier will encroach into the opposing lane. This is permissible when the barrier placement requirements dictate because not all hits will develop the full deflection, the encroachments will be momentary, and the limited encroachment is preferable to allowing a vehicle to enter the opposing traffic unchecked. In addition, many cases may occur where the cable is an interim safety measure until more extensive reconstruction can be accomplished.

Provide a deflection space between flexible median barriers and other barrier systems. Where the length of a flexible barrier and another barrier type overlap, the length of need points of the two systems should overlap where connected by a 25° departure path from the traveled way; see Figure 38-7.D. Where it is not possible to overlap the coverage, provide at least 10 ft (3 m) between the systems; see Figure 38-7.E, or avoid any overlap by ending the flexible barrier at least 10 ft (3 m) before reaching the other type. Another option for avoiding conflicts between different barrier types is to begin runs of flexible barrier at the departure end s of bridges; see Figure 38-7.F.

Where sufficient deflection distance cannot be provided, contact the Bureau of Safety Engineering for guidance.

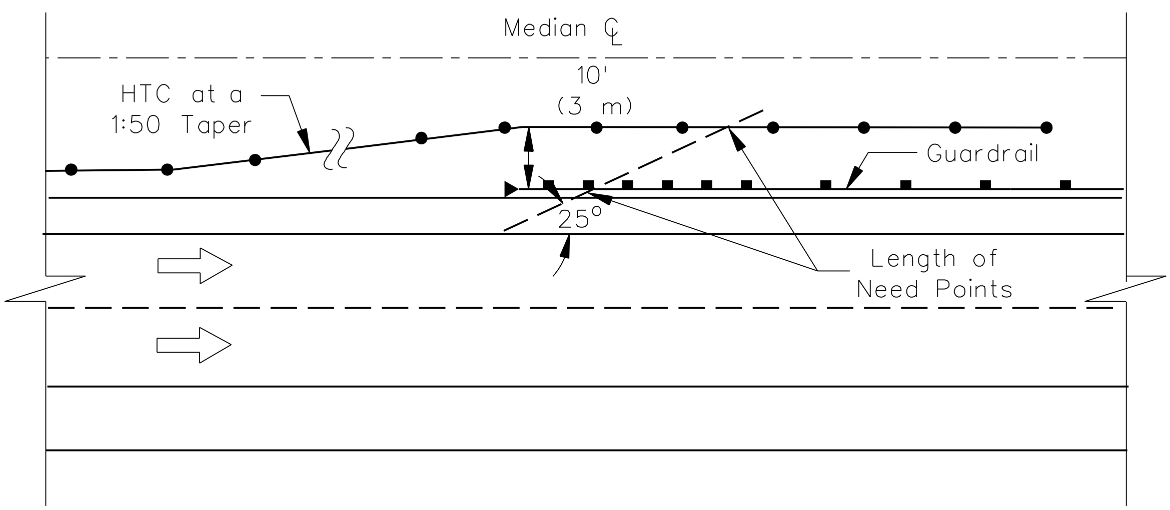
f. Length of Installation. Very long installations (more than 3 miles (5 km)) of HTC may be possible; review manufacturer's recommendations. However, the designer should remember that an impact at the terminal will release tension throughout the entire run of cable. The designer should weigh the advantages and disadvantages of long runs of barrier versus the loss of performance during the time between a terminal hit and its repair.

Very long runs of HTC will also inhibit turnarounds by police and emergency first responders.



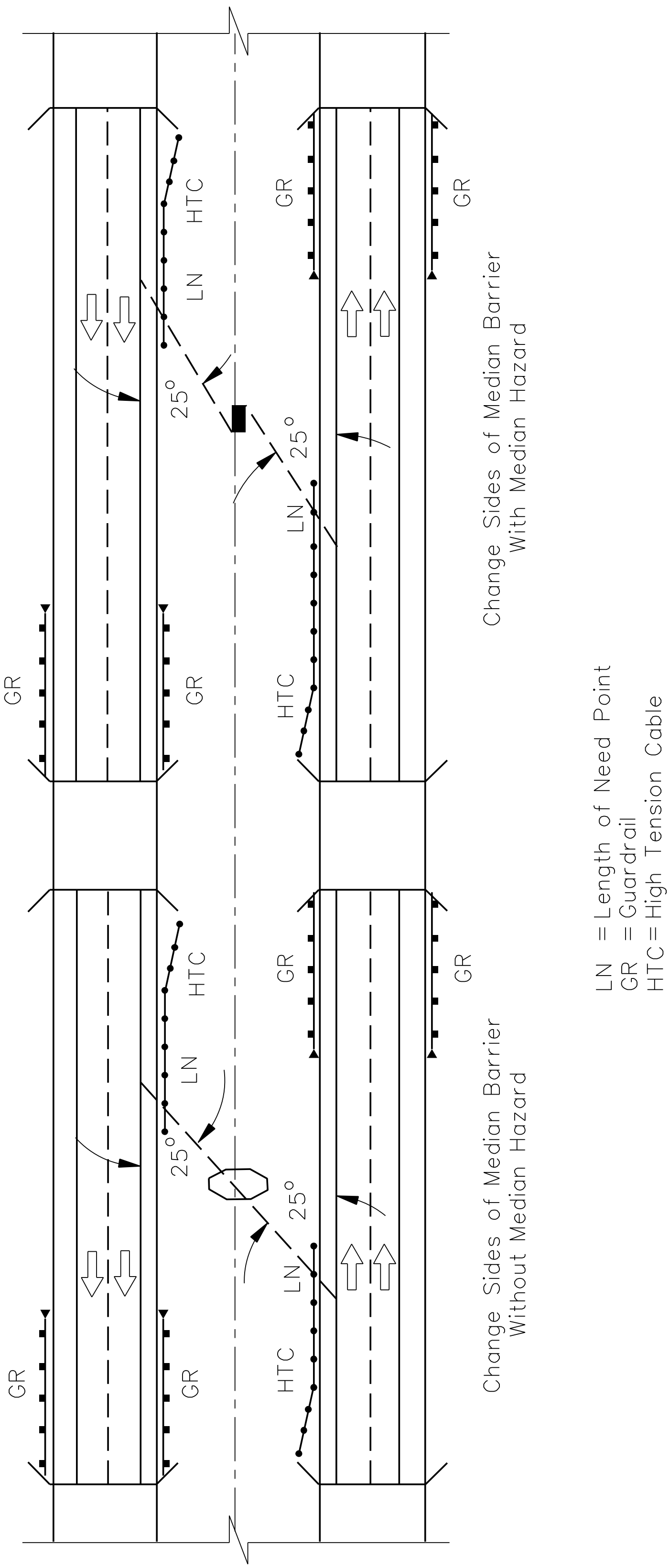
HIGH TENSION CABLE OVERLAPPED IN FRONT OF GUARDRAIL

Figure 38-7.D



HIGH TENSION CABLE OVERLAPPED BEHIND GUARDRAIL

Figure 38-7.E



COORDINATION OF HIGH TENSION CABLE WITH STRUCTURES AND CROSSOVERS

Figure 38-7.F

g. Alignment. HTC will not accommodate abrupt changes in vertical alignment. Crossing of abrupt sags will leave the cable too high. Crossing of abrupt crests will place severe downward stress on cable supports, and will result in low cable height after one impact. These issues are minimized with an installation along or near a shoulder and must be addressed for locations closer to the median center. Breaking and overlapping the runs of HTC at crest or sags is a strategy to minimize this effect, and may also be coordinated with changes in the preferred side of installation.

If the radius of horizontal curvature is 1200 ft (366 m) or less, check the manufacturers' recommendations to confirm which systems may be used.

When placing HTC near a shoulder around a curve, consider locating it where the near traffic is making the left-hand curve (inside of curve relative to near traffic). This may reduce nuisance hits and allow more vehicles leaving the opposing roadway to come to a stop in the median before reaching the barrier.

h. Elevation Differences. Where one roadway is significantly higher than the other, it is generally preferred to place the median barrier along the higher roadway. This consideration should be balanced along with the alignment considerations; see Item g. above.

i. Delineation. Where the HTC is placed along a shoulder, apply reflective caps, reflective tape, or reflectors to the posts of the system at spacing and offsets similar to those used for guardrail reflectors.

j. Coordination. It is important to involve local emergency responders during Phase I development, at the preconstruction meeting, and any hands-on demonstrations provided by the HTC manufacturer. Cutting of cables should be discouraged. Replacement/splicing of cut cables is much more expensive and time consuming than resetting of intact cables. Contractor and manufacturer personnel can instruct emergency responders about alternatives to cutting cables and methods to disengage vehicles. Also, coordinate with emergency responders to ensure safe median and shoulder access is provided.

38-7.04 Median Barrier Layout

Much of the information presented in Section 38-6 on roadside barrier layout also applies to median barriers (e.g., placement behind curbs). The following sections present criteria specifically for the design of median barriers.

38-7.04(a) Sloped Medians

Slopes in the median affect the performance of a barrier. A vehicle traversing a slope, or transitioning between two slopes, prior to impact may not impact the barrier with all four tires on the ground, may have its suspension compressed, or may have a tendency to roll. Where the impact is made under these types of conditions, the crash results may be undesirable. The recommendations for median barrier type and placement considering slopes are shown in Figure 38-7.B.

38-7.04(b) Flared/Divided Median Barriers

It may be necessary to intermittently flare a barrier from one side of the median to the other or to divided a median barrier. A sloped median, a fixed object in the median, and twin separate bridges may require this. The median barrier may be divided by one of the following methods:

1. Rigid Median Barriers. A fixed object may be encased within a concrete barrier or a single-faced concrete barrier may be placed on both sides of a fixed object, see Figure 38-7.G.

2. Semi-Rigid Median Barriers. Steel plate beam guardrail, Type D may be divided into two separate runs of guardrail passing on each side of the median hazard (fixed object or slope), see Figure 38-7.H.

3. Flexible Median Barriers. HTC barriers may be placed on either or both sides of a median hazard, provided adequate deflection distance is available. If the HTC runs on only one side of the hazard, a roadside barrier or impact attenuator to protect traffic in the opposing direction should be used as needed.

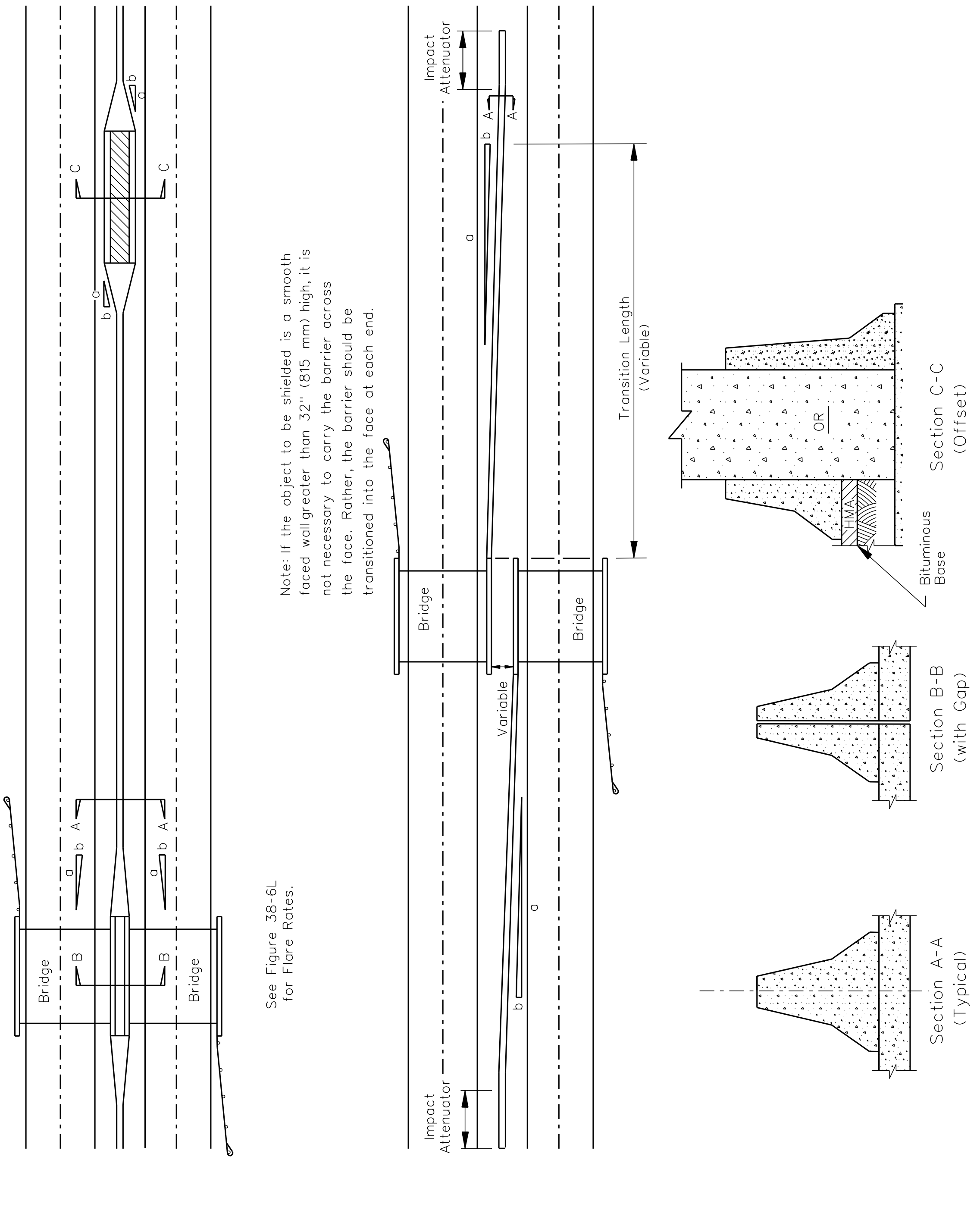
Flare rates for rigid or semi-rigid systems should be according to the guidelines for roadside barriers. Flexible barrier may be flared at 1:50.

38-7.04(c) Barrier-Mounted Obstacles

The designer may consider an additional factor when a concrete barrier divides to pass on either side of an obstacle or when obstacles are mounted on top of a concrete barrier (e.g., luminaire supports). If trucks or buses impact the concrete barrier, their high center of gravity may result in a vehicular roll angle which possibly will allow the truck or bus to impact the obstacle on top of the concrete barrier. Two potential countermeasures are to:

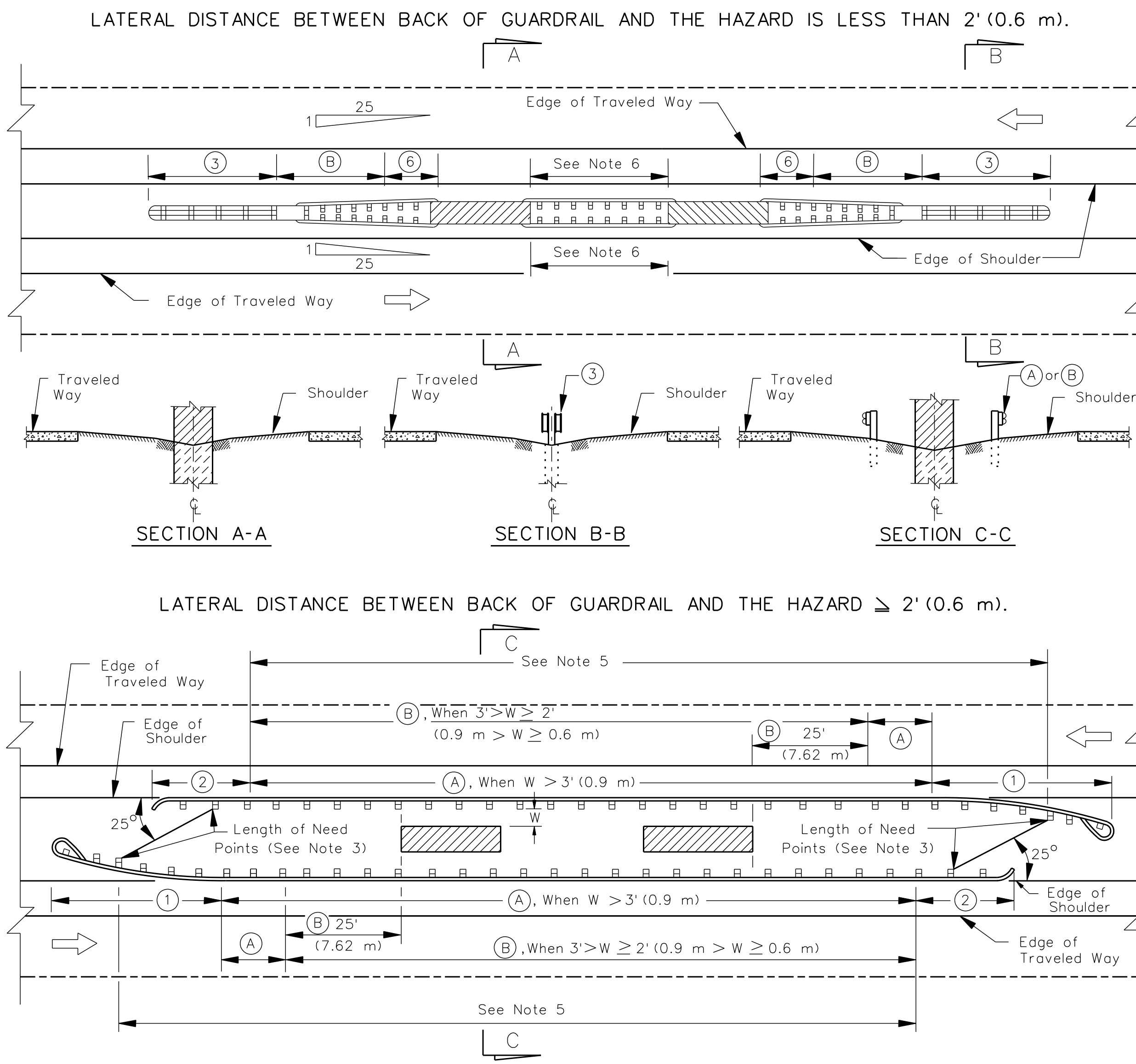
- provide a 2 ft (600 mm) deflection distance between the barrier and obstacle (e.g., bridge piers); or

- use the 42 in (1070 mm) concrete barrier.



FLARING/DIVIDING CONCRETE BARRIER

Figure 38-7.G



Notes :

1. Traffic Barrier Terminal Types:
   - ① Type 1 (Special)
   - ② Type 2
   - ③ Impact Attenuator
   - ④ Type 6 or 6B
2. Steel Plate Beam Guardrail Types:
   - Ⓐ Type A
   - Ⓑ Type B
3. Determing guardrail length of need according to Section 38-6.
4. Where shoulder front slope is 1V:6H or steeper, locate guardrail at shoulder edge.
5. Total length of barrier includes length of need on each end of the hazard plus the length required immediately adjacent to the hazard. See Section 38-6.01.
6. Close gap between piers with concrete barrier, or connect Type 6 or 6B terminals to each, and maintain 18.5" (470 mm) post spacing and nested thrie beam from pier to pier.

Drawing not to scale.

DIVIDING STEEL PLATE BEAM GUARDRAIL

Figure 38-7.H

38-7.04(d) Terminal Treatments

As with roadside barrier terminals, median barrier terminals present a potential roadside hazard for run-off-the-road vehicles. Therefore, the designer must carefully consider the selection and placement of the terminal end. Where practical, the median barrier should be extended into a wider median area. The following NCHRP Report 350 terminals are used by the Department for median barriers:

1. Rigid Median Barriers. The end of a concrete barrier is typically shielded with an impact attenuator. The Department maintains an approved list on its website.

2. Semi-Rigid Median Barriers. Steel plate beam guardrail, Type D is typically shielded with an impact attenuator.

3. Flexible Median Barriers. HTC barriers have their own proprietary terminals. The terminals included in the Department's approved list meet the requirements of NCHRP Report 350. There is at least one terminal listed for each of the approved cable systems.

38-7.04(e) Superelevation

Chapter 32 discusses superelevation development for multilane divided facilities. Where a median barrier is present, the axis of rotation is typically about the two median edges. This will allow the median (and the barrier) to remain in a horizontal plane through the curve. See Chapter 32 for more information.

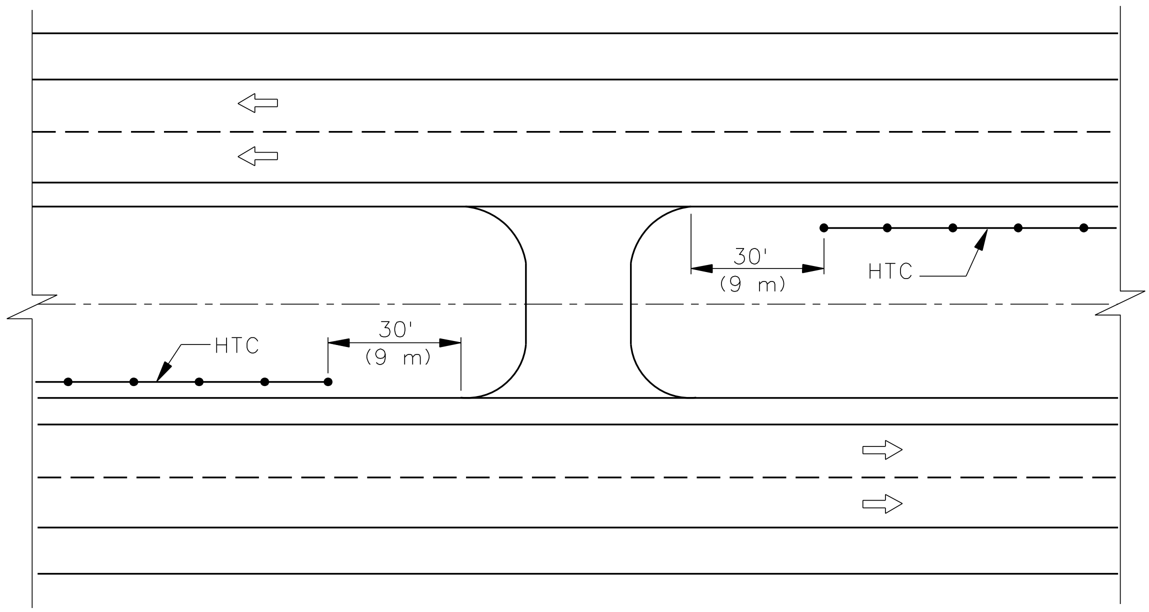
38-7.04(f) Median Crossovers Locations

1. Permanent Locations. Chapter 44 provides guidance and further reference for the location and design of permanent median crossovers. Proper installation of median barriers must take permanent median crossovers into account as there will be a break in the barrier. Where is break is exposed to approaching traffic, it will require treatment according to Section 38-7.04(d). Consider the following:

    a. The most common method for providing an opening in a median barrier for a permanent crossover is to establish a gap in the barrier.

    b. For rigid or semi-rigid barriers, the gap should fit the geometry of the permanent crossover and provide the required throat width for the crossover, plus allowance for any radii or flares.

    c. For flexible barriers, keep the end anchorage location about an additional 30 ft (9 m) away from the completion of the radii or flares. This will help to prevent damage to the terminals that would release tension on the entire run of barrier. Also, for HTC consider changing sides of the median at median crossovers. This will provide slightly better length of need coverage and also provide an opportunity to introduce the change of sides for reasons discussed in Section 38-7.03(b) and as shown in Figure 38-7.I.



HIGH TENSION CABLE AT MEDIAN CROSSOVERS

Figure 38-7.I

d. Median crossovers may also be provided for rigid barriers by overlapping the ends to provide continuous length of need, while leaving a gap that can be navigated by emergency vehicles. This method will require a more complex maneuver for the emergency vehicle and may introduce alignment changes for the through lanes to incorporate the necessary offset of the barriers.

e. Proprietary barrier gates are available for concrete median barriers. These gates are opened by manual means or by electric motors depending on the brand and options selected. These gates should only be used on a case-by-case basis and when supported by a decision according to Section 63-1.04(b).

2. Temporary Locations. For HTC barriers it is possible to create or anticipate temporary locations for emergency use.

a. Where socketed posts are used, it is possible to remove the cables from a sufficient number of posts, or disconnect the cables at the turnbuckles, and create slack. Once cable slack is present, sufficient posts may be removed to create temporary crossover locations.

b. Careful selection of well-drained locations for changing sides for HTC can allow emergency vehicles to make serpentine moves across the median were soil conditions are sufficient stable. For example, this may indicate ditch check locations or pier locations.

38-7.05 Glare Screens

38-7.05(a) General

Headlight glare may be defined as a sensation experienced when a person's vision is interrupted by a light source which has a much higher intensity than the surrounding area. It is frequently cited as a major contributing factor in nighttime crashes that occur on unlighted highways. The magnitude and severity of headlight glare depends on various combinations of a wide variety of factors, including:

- headlight systems, which include the headlight configuration, mounting height, and output intensity;
- roadway features, which include the roadway alignment, geometrics, and pavement reflectivity;
- transmission media, which includes the atmosphere and physical features through which the light must pass, such as windshields and eyeglasses; and
- human variables, which include driver's age, visual ability, and fatigue.

Depending on the severity and effect glare has on a driver, it may be classified as discomfort or disability glare, defined as follows:

1. Discomfort. Discomfort glare does not necessarily impair the vision. However, it frequently causes drivers to become tense and apprehensive, which increases the level of fatigue and may lead to driver error. This type of glare is common and usually occurs where median or outer separator widths are greater than approximately 30 ft (10 m).
2. Disability. Disability glare definitively impairs a driver's vision, frequently causing temporary blindness; consequently, it should be addressed whenever practical. Disability glare occurs usually where median or outer separator widths are less than approximately 30 ft (10 m) in width, on horizontal curves, and/or where transitions alter the highway alignment.

38-7.05(b) Warrants

As indicated, headlight glare from opposing traffic can be bothersome and distracting. Glare screens can be used with or without median barriers to eliminate the problem and should be used when no other practical alternative exists to eliminate disability glare (e.g., wider median, outer separation, highway lighting, landscaping). The designer should consider if the following conditions exist when determining the need for a glare screen:

- unlighted divided highways where design speeds are 50 mph (80 km/h) or greater and medians 30 ft (9 m) or less in width;
- horizontal curves on divided highways;
- points where the separation between a mainline and frontage road is minimal and alignment is such that mainline traffic is affected by the lights of vehicles using the frontage road;
- points of transition which create critical glare angles between opposing vehicles;
- locations where nighttime crash rates are unusually high; and
- any location where conflicting light sources cause a distorted or confusing view of the driver's field of vision.

IDOT has not adopted specific warrants for the use of glare screens. The typical application, however, is on urban freeways with narrow medians and high traffic volumes. Another application is between on/off ramps at interchanges where the two ramps adjoin each other. Here, the sharp radii and the narrow separation may make headlight glare especially bothersome. The designer should consider the use of glare screens at these sites. A key element warranting their use is the number of public complaints IDOT may have received for a highway section.

38-7.05(c) Glare Screen Types

The following describes the glare screens used by the Department:

1. Concrete Glare Screen. Where a glare screen is warranted for a section of roadway with concrete barrier, the designer may specify a concrete glare screen. See the *Illinois Highway Standards* for details. This type of glare screen is advantageous on high-volume routes due to its low maintenance.

2. Glare Screen Blades. As an alternative to the concrete glare screen, a series of thin vertical blades may be mounted on top of the concrete barrier. The designer must specify the spacing, height, and longitudinal spacing of the blades on the plans. See the *Illinois Highway Standards* for details.

3. Chain Link Fence. If a median barrier is not warranted but a glare screen is warranted, the designer should install a chain link fence glare screen using a fabric woven with a maximum 1 in (25 mm) opening between parallel wires. In addition to alleviating glare, the fence will control access across the median. This type of glare screen is also effective in controlling glare between the mainline and adjacent frontage roads because an access control fence is usually required.

38-7.05(d) Glare Screen Design

The following applies to the design of a glare screen:

1. General. Glare screens must not be used as a wind or snow shield nor should they detract from the aesthetics of the highway. However, they should be durable and easy to maintain.

2. Cutoff Angle. Glare screens should be designed for a cutoff angle of 20°. This is the angle between the median centerline and the line of sight between two vehicles traveling in opposite directions. See Figure 38-7.J. The glare screen should be designed to block the headlights of oncoming vehicles up to the 20° cutoff angle. On horizontal curves, the design cutoff angle should be increased to allow for the effect of curvature on headlight direction:

$$\text{Cutoff Angle (in degrees)} = 20 + \frac{5729.6}{R} \qquad \text{(US Customary)}$$

$$\text{Cutoff Angle (in degrees)} = 20 + \frac{1746.8}{R} \qquad \text{(Metric)}$$

   Where:

   R = radius of horizontal curve in feet (meters)

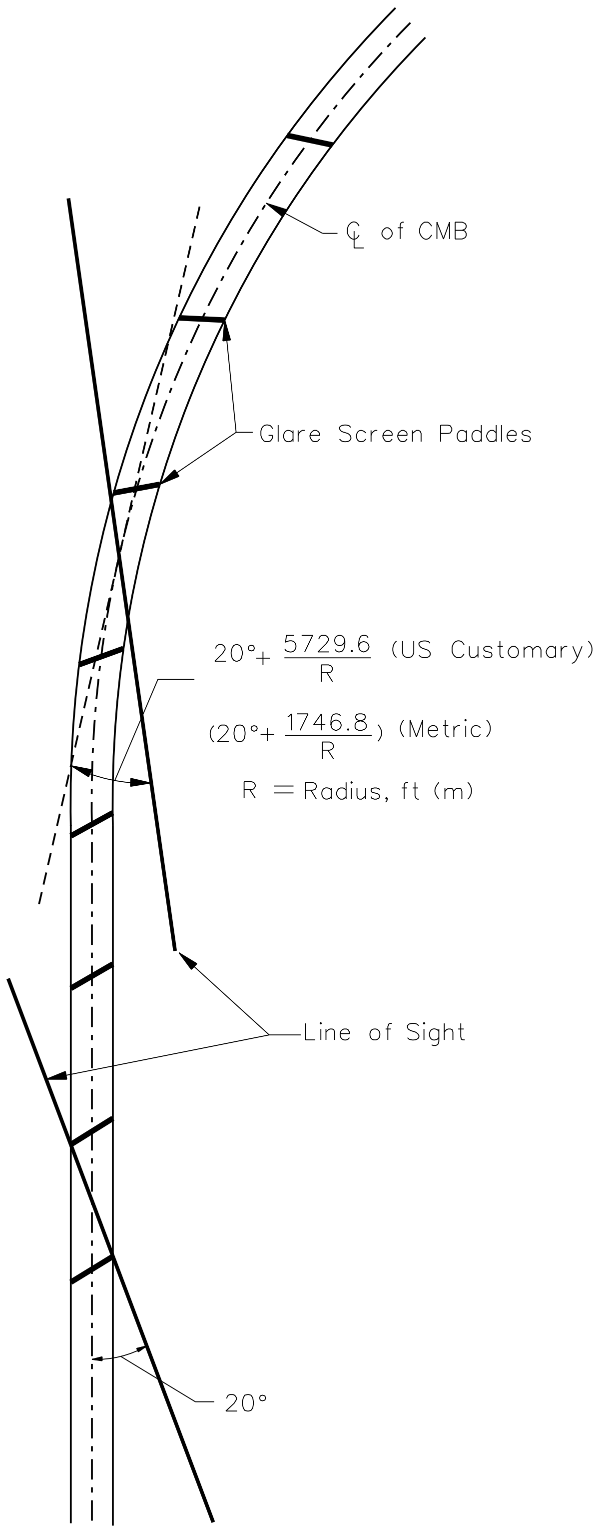
3. Horizontal Sight Distance. Glare screens may reduce the available horizontal sight distance. For curves to the left, the designer will need to check the middle ordinate to determine if adequate stopping sight distance will be available. See Section 32-4.

4. Sag Vertical Curves. When determining the necessary glare screen height, the designer may ignore the effect of sag vertical curvature.

5. Height of Eye. The average driver's eye height is 3.5 ft (1080 mm) for passenger vehicles and 7.6 ft (2.3 m) for large trucks. These heights are average and must be adjusted when determining extreme conditions.

6. Glare Screen Height. The upper and lower elevations of the glare screen must be such that light does not shine over or under the barrier. The height of glare screens may be established by examining the following factors:

   - height of driver's eye in relation to the pavement,
   - height of the headlights of various size vehicles in relation to the pavement, and
   - changes in elevation across the entire roadway width including the median.



CUTOFF ANGLE FOR GLARE SCREENS

Figure 38-7.J

7. <u>Coordination of Glare Screen with Concrete Barrier</u>. The preceding steps cover design of glare screen. However, calculation of detailed height requirements does not imply that the height of glare screen should vary repeatedly from location to location along a job. As with the design of concrete barrier, select the height to bracket the needs of the section or logical segments. In addition, the height to the top of glare screen should be determined using standard devices and the following steps:

   a. If the 32 in (815 mm) barrier is being used and glare screens are needed, the most likely application will be to add a glare screen to the 32 in (815 mm) barrier.

      However, consideration may be given to using the 42 in (1065 mm) barrier alone or with a glare screen. While the 42 in (1065 mm) barrier may not be necessary for truck volumes, it will both increase truck crashworthiness and raise the effective height of the glare screen. This is most likely to happened either if truck volumes are negligible so that the 42 in (1065 mm) height will suffice or where a height of more than 51 in (1295 mm) is required.

   b. For locations where the 42 in (1065 mm) barrier is required, the concrete glare screen may be added to reach a height of 61 in (1550 mm). If heights greater than 61 in (1550 mm) are required, then glare screen blades or special designs using concrete may be considered. The addition of taller concrete barrier or concrete glare screen raises issues regarding control of debris scatter from a collision, as well as the necessary shape and slopes for the taller sections. Contact BDE to coordinate any designs using concrete glare screens above a height of 61 in (1550 mm).

* * * * * * * * * *

<u>Example 38-7.05(1)</u>

Given: Six-lane divided highway
12 ft travel lanes
2% pavement cross slope
5 ft median width

Problem: Determine the upper and lower elevations of the glare screen.

Solution: First, determine the lower elevation based on the following factors:

1. The most severe condition is two sport cars traveling in opposite directions each using the right-hand lane.

2. The eye level of the drivers is 3 ft above the pavement.

3. The lower edge of the sport car’s headlights is 1.75 ft above the pavement.

4. The driver's eyes are approximately 8.75 ft from the outer edge of the traveled way.

5. Figure 38-7.K presents the determination of the lower edge of the glare screen.

Next, determine the upper elevation based on the following factors:

1. The most severe condition is two large trucks traveling in opposite directions, one using the right-hand lane and the other using the left-hand lane.

2. The eye level of the drivers is approximately 7.6 ft above the pavement.

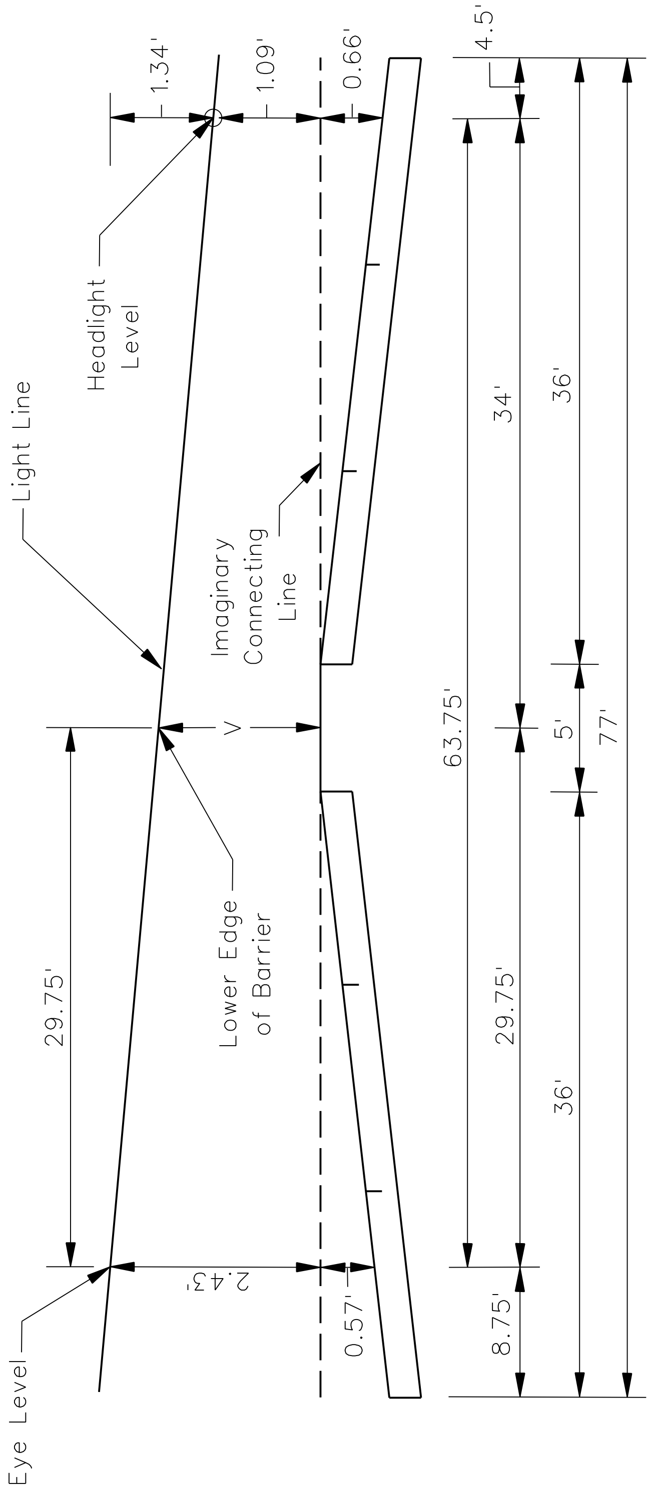
3. The lower edge of the truck headlights is 3.75 ft above the pavement.

4. The eye of the driver using the left-hand lane is approximately 5.75 ft from the median centerline.

5. The left headlight of the truck using the right-hand lane is approximately 4.5 ft from the outer edge of the traveled way.

6. Figure 38-7.L presents the determination of the upper edge of the glare screen.

For most locations, it is not necessary to use this upper level. See Section 38-7.05(c).

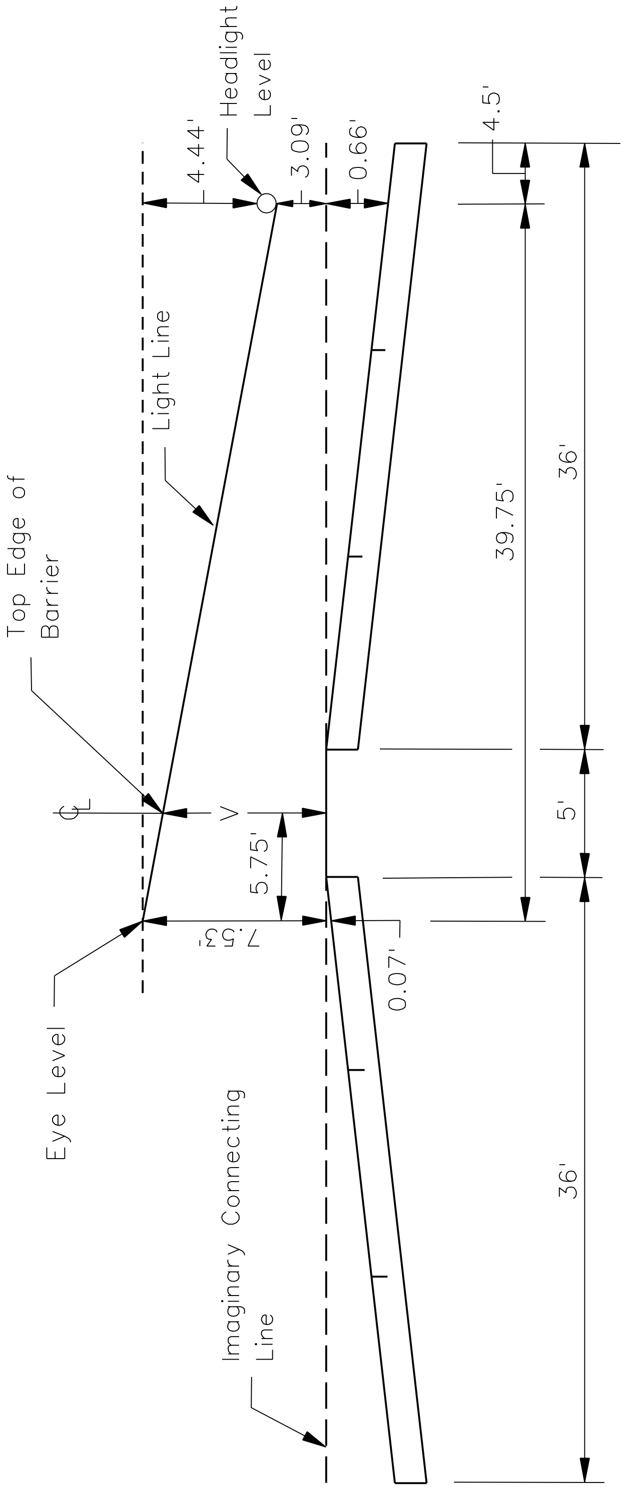


$$V = 2.43 - \left(\frac{1.34}{63.75}\right)(29.75)$$

$$V = 1.84'$$

LOWER ELEVATION OF GLARE SCREENS
(Example 38-7.05(1))

FIGURE 38-7.K



$$V = 7.53 - \left(\frac{4.44}{39.75}\right)(5.75)$$

$$V = 6.89'$$

UPPER ELEVATION OF GLARE SCREENS
(Example 38-7.05(1))

Figure 38-7.L

38-8 IMPACT ATTENUATORS (Crash Cushions)

38-8.01 General

Impact attenuators (crash cushions) are protective systems that prevent errant vehicles from impacting hazards by decelerating them to a stop after a frontal impact, by redirecting them away from the hazard, or by decelerating them after a side impact. They operate on the basis of either energy absorption or momentum transfer. Impact attenuators are adaptable to many roadside hazard locations where longitudinal barriers cannot practically be used.

38-8.02 Warrants

Regardless of median width, all piers, sign foundations, and similar hazards in medians of divided highways warrant shielding with an impact attenuator(s) or other systems acceptable under NCHRP Report 350. For extreme median widths (greater than 84 ft (26 m)), exceptions should be considered on a case-by-case basis.

Impact attenuator warrants are the same as barrier warrants. Once a hazard is identified, the designer should first attempt to remove, relocate, or make the hazard break away. If the foregoing is impractical, then an impact attenuator should be considered.

Impact attenuators serve two principal functions. They may be installed as stand-alone devices to shield point hazards (e.g., bridge piers, sign foundations) or they may be used as terminal treatments for roadside or median barrier systems. Where used to shield a point hazard, the impact attenuator is placed very near or in contact with the hazard; therefore, no length of need applies and no additional barrier is required. This can only be done where the shoulder and/or foreslope in the runout area is 1V:10H or flatter and other aspects of the required impact attenuator layout (e.g., pad or base, physical room for the system) can be accommodated. Otherwise, a roadside barrier or median barrier, as appropriate should be used. An impact attenuator or other NCHRP Report 350 approved terminal treatment will be required for the barrier.

38-8.03 Impact Attenuator Types

38-8.03(a) Overview

Selection of the most appropriate impact attenuator type depends on a variety of factors:

1. Redirective Properties. The impact attenuator devices have various properties related to the path of a vehicle after impact.

2. Operational Principles. The systems have varied means to deal with the energy or momentum impacted by an impact.

3. Maintenance and Repair Issues. Some systems retain residual capacity to absorb additional frontal impacts during the time between an initial crash and full repair of the

system. Systems vary in the cost and effort required for repair of crash and nuisance hits.

4. Device Approval Status. To be considered for use on Illinois highways, a given device must be on the Department's approved list.

5. Physical Placement Requirements. The size, layout and anchorage requirements may dictate or eliminate various systems depending on the type of location where protection is required.

6. Costs. Given the wide variation in the approaches to the above considerations, the systems vary in cost of installation and repair. Life cycle cost analysis using the Roadside Safety Analysis Program (RSAP) may be a useful tool.

7. Pedestrians/Bicyclists. In some installations, impact attenuators may be introduced into the pedestrian/bicyclist environment. This will require consideration of various factors to evaluate the relative risks to the vehicular traffic and pedestrian/bicyclist traffic.

All of these factors, taken together guide the impact attenuator selection.

38-8.03(b) Redirective Properties

A vehicle is redirected when it safely stays on the same side of the item it strikes. NCHRP Report 350 provides further criteria to define safe redirection.

1. Fully Redirective Devices. A fully redirective device will safely redirect a vehicle that impacts at any location along the face of the device.

2. Partially Redirective Devices. A partially redirective device will safely redirect a vehicle that impacts downstream of a given length of need point along the length of the device. This type of device will allow a vehicle impacting between the length of need point and the free end of the impact attenuator to pass through to the area behind the device.

3. Non-Redirective Devices. A non-redirective device will either capture an impacting vehicle or allow it to pass through when hit along the face of the device.

38-8.03(c) Operational Principles

1. Energy Absorbing Devices. This type of impact attenuator operates on the principle of absorbing the energy of the vehicle by various means, including crushing or deformation of engineered modules or by compression of a hydraulic cylinder. Some energy is also absorbed by the impacting vehicle as the front end of the vehicle is crushed on impact. Energy absorbing attenuators require rigid back-up support or connection to another barrier system to contain the forces created by the deformation of the device. This support may be supplied as part of the impact attenuator or may be derived from its connection to the barrier or hazard (e.g., concrete structure). This distinction may

preclude the use of some system for shielding point hazards that will not provide this support. In these cases, a special provision limiting the selection to no less than two alternatives may be required. This type of device also requires vertical and lateral anchoring. This is accomplished by attachment to a bituminous or concrete base or by placement of posts. Devices of this type capture or rebound the vehicle in a frontal impact. For side impacts, the devices work either as fully redirective or partially redirective.

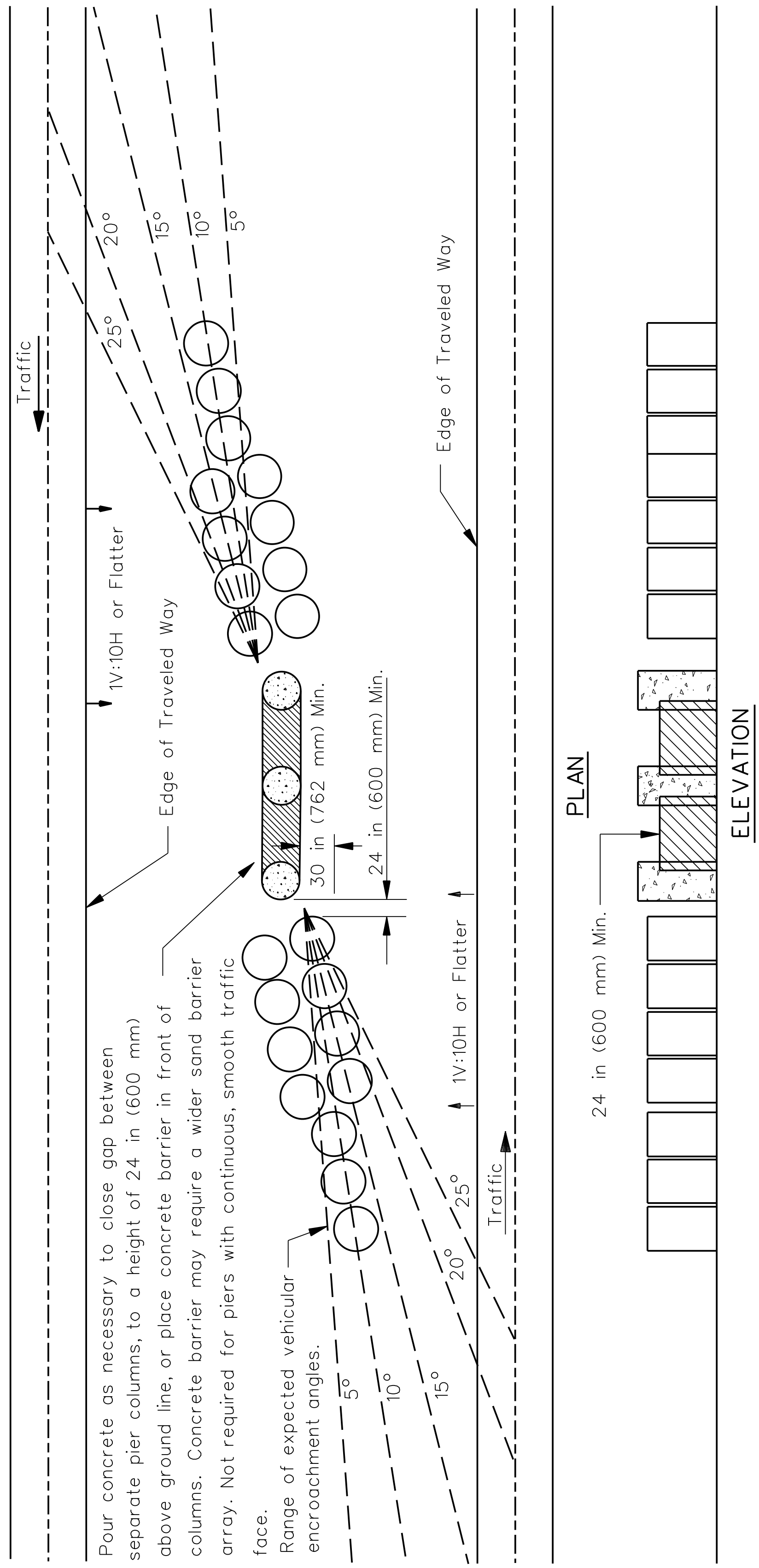
2. Momentum Transfer Devices. This type of system operates by transferring the momentum of an impacting vehicle to an expendable mass of material contained in the device.

   a. Sand Modules. A typical momentum transfer device is an array of sand-filled plastic modules. Sand module configurations meeting NCHRP Report 350 requirements are available to accommodate various speeds and widths. However, arrays with only one row of barrels are not approved for use by the Department. Information is available from the various manufacturers regarding their NCHRP Report 350 accepted configurations.

      The sand module systems require no back-up support or connection to another system. However, they do require that the modules be placed on a bituminous or concrete base. Sand modules have no redirective capability and generate considerable debris upon impact. On approaching traffic corner, the exterior modules must be laterally offset at least 2.5 ft (750 mm) from the corner of the hazard; see Figure 38-8.A.

      The sand module impact attenuator design should allow for safe side impacts. Figures 38-8.A and 38-8.B illustrate two methods to modify the sand module design to accommodate angle impacts. Figure 38-8.A illustrates how the modules may be shifted to afford attenuation at the end points and direction along the sides of the hazard by closing or covering the gap between pier columns. Figure 38-8.B illustrates where the side of the hazard and available space are such that full protection, through attenuation only, can be provided by the use of additional modules to widen the standard array. Although the entire area of the hazard must be shielded from angle impacts either by attenuation or redirection, the permissible attenuation may be varied to optimize space and economy. The layout of the sand module arrays should be as accepted under NCHRP Report 350 or designed to meet NCHRP Report 250 criteria.

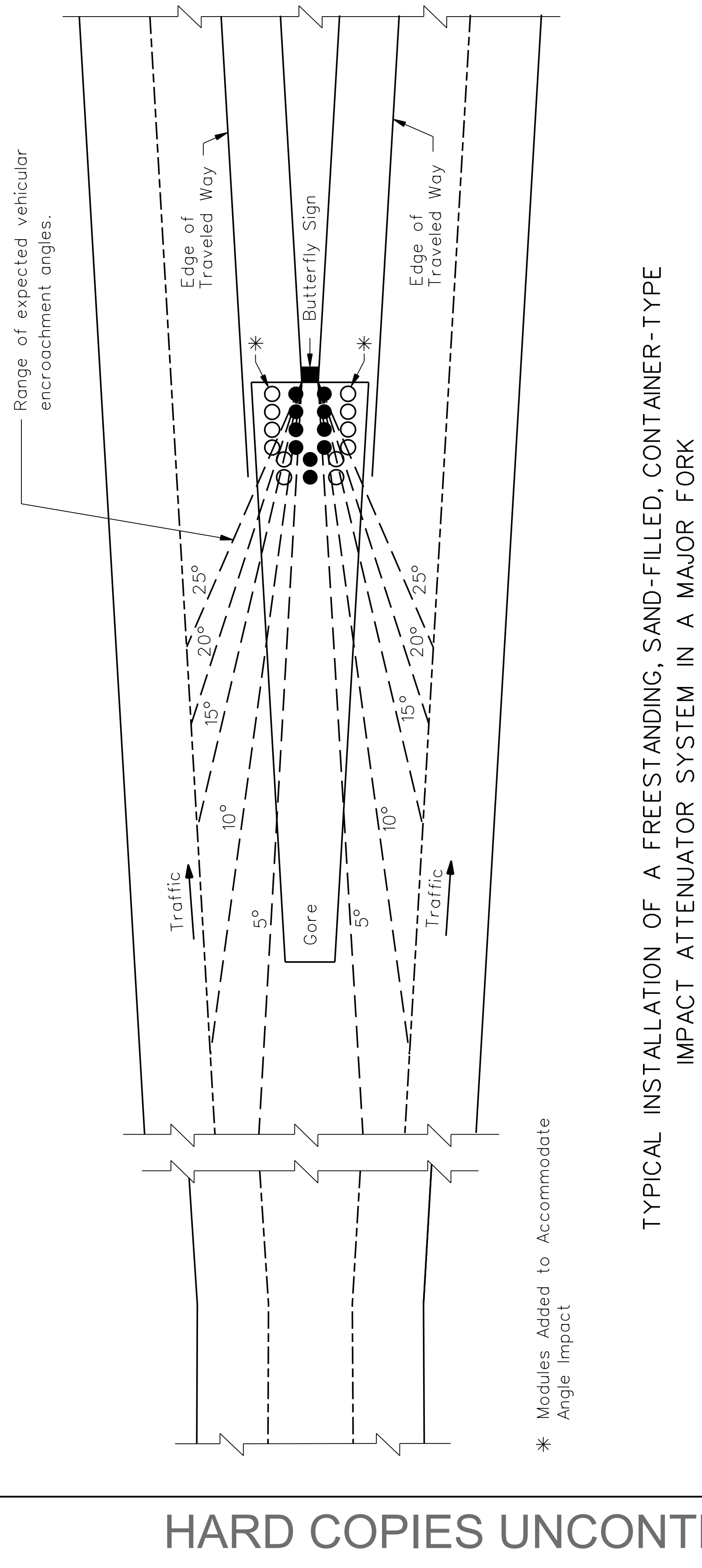
      Include the specific layout of sand modules, including positioning relative to the hazard, in the plans. Note the Test Level for which the array is designed.



TYPICAL INSTALLATION OF A FREESTANDING, SAND-FILLED, CONTAINER-TYPE IMPACT ATTENUATOR IN MEDIAN

ANGLE IMPACT AND POSITIONING DESIGN FOR SAND BARRELS

Figure 38-8.A



ANGLE IMPACT DESIGN FOR SAND BARRELS

Figure 38-8.B

b. Water Filled Impact Attenuator. The water-filled barrier dissipates energy both by energy transfer (crushing of modules) and by momentum transfer to the system's mass. Water filled impact attenuators also have no redirective capability and may spread water in the area of an impact. These impact attenuators are used with temporary barriers and must be attached to the barrier system. They do not require anchorage to the pavement or base. Water filled impact attenuators require less width for placement than do sand module impact attenuators.

Figure 38-8.C gives comparisons of systems based on their operational principles.

38-8.04 Maintenance and Repair Considerations

Some systems require extensive repairs or replacement after a full speed impact, while some others may only require minor adjustments and/or replacement of drop-in modules or simply resetting with minimal repair parts. Additionally, some systems retain partial capability to shield a hazard after an initial impact and before repair.

Sand modules are particularly vulnerable to nuisance hits from mowers or wide vehicles. Such occurrences may puncture the plastic modules and cause loss of sand, thereby rendering the devices ineffective. Care should be taken to provide some buffer space on the pad for sand modules to allow for mower overhang. A minimum suggested buffer is 12 in (300 mm) along the sides and front of the array.

Impact attenuators that incorporate tracks or guides anchored to a base may be subject to accumulation of road debris (e.g., sand and silt). In extreme cases and conditions these may interfere with the operation of the attenuator. Generally, attenuator locations should be kept out of depressed locations or other sites that encourage deposition of debris. Where this is unavoidable, the designer may "write out," by special provision, any specific impact attenuators that have critical moving parts (e.g., tracks, guides, rollers, cables) near the ground line.

38-8.04(a) Resettable Devices

Resettable devices are those that do not usually require significant repair parts, but may require work to return the system to a crashworthy configuration ready for the next impact. The initial cost for these systems is intermediate between severe use (see Section 38-8.04(b)) and other fully-redirective devices. These devices are cost-effective where significant impacts may occur one or more times in a three year period. Spreadsheets are available for more detailed analysis. Contact the Bureau of Safety Engineering for more information.

There is no specification for wide impact attenuators in the resettable category. This is because the available systems vary in their treatment of this issue. Where a wide hazard is to be shielded with a resettable attenuator, the designer may prepare a special barrier transition from the hazard to the attenuator connection. See the manufacturer's specifications and drawings as well as Section 38-6.05.

Operational Principal	Advantages	Disadvantages
Energy Absorbing Devices	1. Little or no debris after a hit. 2. Ease of maintenance after a hit. 3. Some systems retain partial attenuation capacity after a hit. 4. Relatively low maintenance cost to repair after a hit. 5. Protection from pocketing at transition from impact attenuator to hazard. 6. Adaptable to very narrow hazards.	1. Possible high initial cost. 2. Considerable site preparation (e.g., pad, back-up structure, mounting bolts or anchors). 3. IDOT pay items and specifications will cover hazards up to only 90 in (2.25 m) wide. See Section 38-8.06.
Momentum Transfer Devices (Sand Modules)	1. Relatively low initial cost. 2. Ease of installation. 3. Versatile; can be used to cover a large area.	1. Considerable debris after a unit is hit. 2. Relatively high maintenance cost to repair after hits). 3. Generally, no residual attenuation capacity after a major hit. 4. No side redirection and little or no protection at transition for impact attenuator to hazard. 5. Considerable inventory of parts and space for replacements required. 6. Modules may “walk” when placed on structures. Contact BDE if this application is required.
Momentum Transfer Devices (Water Filled)	1. Relatively low initial cost. 2. Ease of installation. 3. Little or no site preparation. 4. Does not require anchorage to a paved base. 5. Adaptable to very narrow hazards. 6. After impact, can be restored quickly by two laborers and a water supply/tank.	1. Water on ground or pavement immediately after a hit. 2. Require environmentally friendly antifreeze for cold weather application. 3. Attaches only to concrete barrier, although the barrier may transition then to other systems. 4. Generally, no residual attenuation capacity after a major hit. 5. No side redirection. Must be placed beyond the length of need point. 6. Modules may “walk” when place on cross-sloped structures. Contact BDE if this application is required.

COMPARISON BY OPERATIONAL PRINCIPLE

Figure 38-8.C

38-8.04(b) Severe Use

Severe use applies to installations where the crash cushion should retain some residual capacity to absorb additional frontal impacts while awaiting repairs. The crash cushion should also require minimum cost and time for repairs after an impact. These installations are those where repeated or frequent hits are known or anticipated, and where lane closures to repair the crash cushion need to be kept to a minimum time window.

The residual frontal impact capacity available in the severe use items may be offset by some reduction in redirective capability. The residual capacity is not a substitute for proper inspection and repair after each impact. Also, the elastic components will deteriorate with time and repeated impacts and will require replacement. Some current indications are that about 13 to 15 impacts may warrant replacement.

38-8.05 Device Approval Status

1. Approved Devices. For routine use by the Department, a system must be accepted under NCHRP Report 350 and be on the Department's approved list. The approved list is published as a Special Notice in each Notice of Letting document published by the Department. The designer should note that all of the operational systems are proprietary. Contact BDE for additional information on impact attenuator installations. Also, information regarding NCHRP Report 350 acceptance, crash test results, and descriptive information may be researched through manufacturers' information and on the FHWA Internet web page.

   Unless otherwise noted, all items on the Department's approved list of NCHRP Report 350 devices are crash tested and accepted at Test Level 3. This level of safety is adequate for facilities with normal operational design speeds posted greater than 45 mph. For facilities with normal operational design speeds of 45 mph or less, the designer may specify the use of devices accepted at Test Level 2. Information relative to Test Level 2 devices is included in Figure 38-8.G and in the BDE Special Provisions. Also, see Figure 38-8.G for a partial review and comparison of attributes of various approved systems.

2. Other Devices. There are some devices accepted under NCHRP Report 350, but are not listed on the Department's approved list. See the FHWA Internet website, the AASHTO *Roadside Design Guide*, and the various manufacturers' brochures and Internet sites. A proposed use of these devices must be coordinated with BDE.

Figure 38-8.H correlates the various systems relative to contract pay items.

38-8.06 Physical Placement Requirements

Several factors should be considered in the placement of an impact attenuator:

1. Level Terrain. All impact attenuators have been designed and tested for level conditions. Vehicular impacts on devices placed on an excessively sloped site could result in an impact at an improper height, which could produce undesirable vehicular behavior. Therefore, the attenuator should be placed on a base or pavement slightly sloped to facilitate drainage, but the cross slope should not to exceed 5%, or as allowed by the proprietary specifications. Impact attenuators that require anchorage to the base should not be placed over a break in slope as this can misalign necessary guide rails and other components.

2. Curbs. No curbs higher than 2 in (50 mm) should be constructed at impact attenuator installations. On existing highways, all curbs higher than 2 in (50 mm) should be removed at proposed installations, if feasible.

3. Surface. Many impact attenuator systems require a paved, bituminous or concrete pad. To minimize nuisance hits, especially for sand module impact attenuators, the total base width should be 2 ft (600 mm) wider than the array.

4. Elevated Structures. The unanchored sand modules or water-filled impact attenuators may “walk” due to the vibration of an elevated structure with a cross-sloped surface. This could adversely affect its performance. If it is necessary to place sand modules or water-filled impact attenuators on elevated structures, contact BDE for assistance.

5. Orientation. The impact attenuator should be oriented to accommodate the probable impact angle of an encroaching vehicle. See Figures 38-8.A and 38-8.B for sand modules. This will maximize the likelihood of a head-on impact. However, this is not as important for impact attenuators with redirective capability. The proper orientation angle will depend upon the design speed, roadway alignment, and lateral offset distance to the attenuator. A maximum angle of approximately 10° toward oncoming traffic, as measured between the highway and impact attenuator longitudinal centerlines, is considered appropriate.

6. Location. The system must not infringe on the traveled way. There should be a minimum of 2 ft (600 mm) behind sand module systems and in front of the hazard to allow access to the system. The space or transition behind other impact attenuator systems should be according to the manufacturer’s specifications.

7. Bridge Joints. Avoid the placement of fully or partially redirective impact attenuators over bridge expansion joints or deflection joints in deep superstructures because movement in these joints could create destructive strains on the system’s anchor cables or other continuous parts.

8. Transitions. If required, transitions between systems and backwalls, bridge rails, or other objects are detailed in various proprietary systems. Review the acceptance information and Figure 38-8.G to ensure that systems are approved for bidirectional applications where necessary.

Many impact attenuators can connect to guardrail or to concrete barrier. In these cases, and where the available length allows, width transitions may be designed using a barrier extended back from the impact attenuator to a connection to or protective position in front of the wide hazard. The barrier design and flare rates should be according to Section 38-6 and the *IDOT Highway Standards*. Any flared barrier or impact attenuator may somewhat increase the redirection angle for impacting vehicles.

38-8.07 Cost

The designer should investigate relative costs for items under consideration. In some cases, a premium for fully redirective properties, for a resettable system, or for items for severe use installations will be offset by the maintenance or repair benefits provided. However, the designer should be careful not to apply premium systems where crashes are rare (1 or less expected impact per 10 years). In these cases, consider using simpler, lower priced systems.

Conversely, use of a low-cost, sacrificial system in an area with occasional (up to 1 crash per 3 years) to frequent impacts (2 or more impacts per year) will lead to high costs for repeated replacement of the attenuator.

38-8.08 Pedestrian/Bicyclist Environment

Impact attenuators are designed to contribute to a forgiving roadside for errant vehicles. The crash testing takes place at 60 mph (100 km/h) (nominal) and angles up to 20° for Test Level 3 and at 45 mph (70 km/h) (nominal) and similar angles for Test Level 2 devices. The impact attenuators developed to buffer such crashes are often constructed of steel panels and frames, cables, and steel or wood posts. Also, during an impact, these parts are designed to move, crush, or break in a controlled manner. As result, the impacting vehicle may rotate, rebound, or glance off the impact attenuator.

Placing an impact attenuator in a pedestrian environment imposes compromises and tradeoffs between vehicle occupant safety and pedestrian/bicyclist safety. Consider the following:

- As much as practical, impact attenuators should be placed away from pedestrian/bicyclist facilities. For example, where an impact attenuator must be located at the end of a parapet or wall crossing a bridge, if space permits, extend the wall or parapet beyond the bridge and separate the pedestrian/bicyclist pathway from the wall and roadway before introducing the impact attenuator.

- Evaluation of the tradeoffs between vehicular and pedestrian/safety should include factors contributing to the relative risk for each user class. These include exposure of individuals, quality of the design/design constraints, and expected severity of each crash category.

- Exposure measures include ADT for vehicular traffic, pedestrian volumes and bicycles.

- Measuring the quality of the design includes mainly the offset between the impact attenuator and the roadway and/or pedestrian/bicyclist way along with any constraints on developing the offset.
- To evaluate the expected severity of any crashes, consider the operating speed of the roadway facility, the treatment under consideration (e.g., impact attenuator, blunt end, sloped end), and the nature of any particular impact attenuators.
- Figure 38-8.D offers guidance regarding pedestrian/bicyclist considerations for particular impact attenuators.

Impact Attenuator System or Family	**Pedestrian/Bicyclist Considerations**
QuadGuard	1. Side panels face pedestrians/bicyclists from opposing direction. 2. Gaps should be installed as tight as possible on pedestrian side. 3. Top edge exposed similar to guardrail.
SCI-100GM	1. Side panels face pedestrians/bicyclists from opposing direction. 2. Exposed edges are beveled and should minimize snagging. 3. Side panels remain nested upon head on impact. 4. Gaps should be installed as tight as possible on pedestrian side. 5. Top edge exposed similar to guardrail.
TRACC	1. Side panels face pedestrians/bicyclists from opposing direction. 2. Gaps should be installed as tight as possible on pedestrian side. 3. Top edge exposed similar to guardrail.
TAU-II	1. Same as TRACC.
QUEST	1. Same as TRACC.
REACT 350	1. Heavy plastic drums connected/restrained by steel cables. 2. Steel cables are main hazard to pedestrians/bicyclists on the face. 3. Tops are 4.5 ft (1.4 m) off the ground and should not be hazardous to pedestrians/bicyclists.
CAT-350	1. Similar to guardrail terminal.
Brakemaster 350	1. Similar to guardrail terminal.
FLEAT-MT	1. Similar to guardrail terminal.
Sand Modules	1. Plastic drums weighted with sand. Any spilled sand may affect walking/cycling surface.
ABSORB 350	1. Plastic barrier shape filled with water. 2. Temporary use only. 3. Any spilled water may freeze or otherwise wet the walking/cycling surface.

PEDESTRIAN/BICYCLIST CONSIDERATIONS FOR IMPACT ATTENUATORS

Figure 38-8.D

38-8.09 Impact Attenuator Selection

The selected impact attenuator must be compatible with the specific site characteristics. For each category of device, more than one approved system must be allowed for competitive bidding, unless specific approval is made according to Section 66-1.04(b). Selection of the correct category (pay item) will require comparison and analysis of possible solutions. Factors to consider include:

- type and width of hazard (see Section 38-8.06 on transitions);
- space, or reserve area, available for installation of the system. The reserve area allows for placement of the barrier and any necessary clearances; see Figure 38-8.E);
- whether the hazard to be shielded is located in a high- or low-risk impact area;
- initial, maintenance, and restoration costs; and
- ease or difficulty of restoration of the system after impact. The importance of this factor will be related to the traffic and hazard levels at a site. More traffic and higher hazards will make speedy repair or replacement a higher priority.

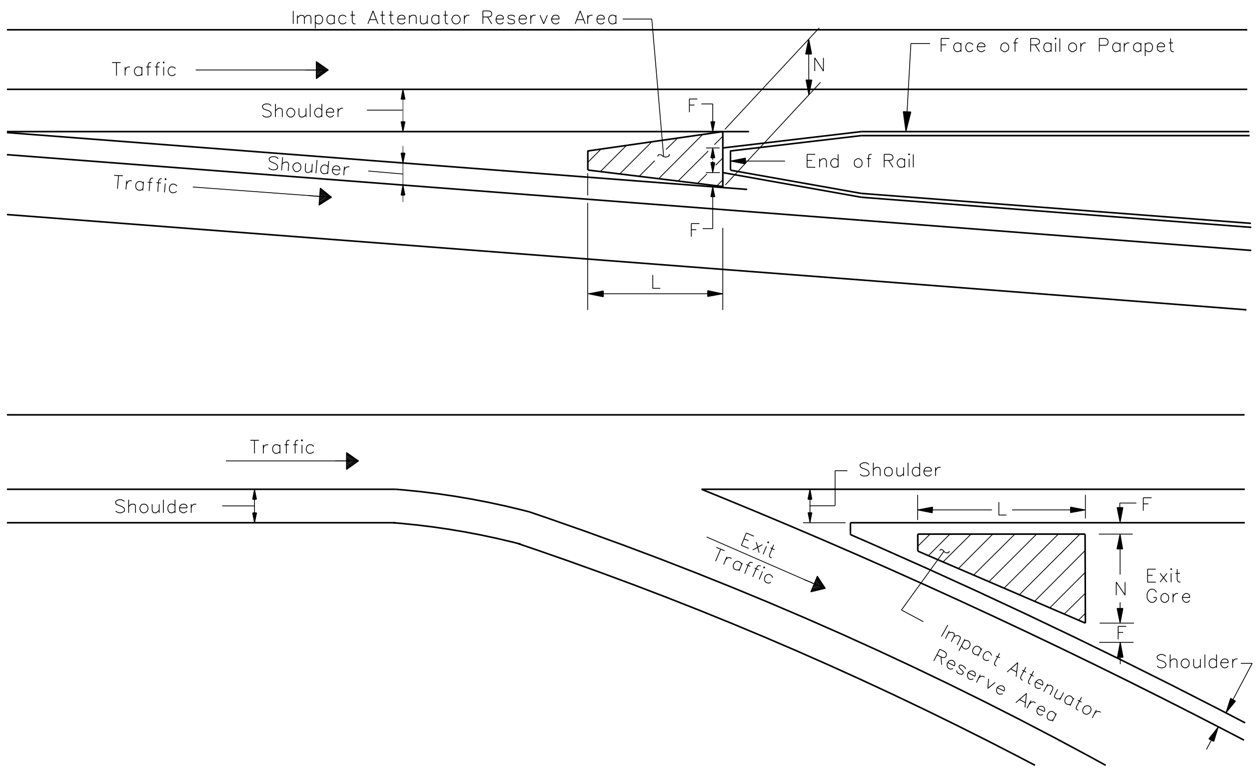
Figure 38-8.F summarizes the advantages and disadvantages of the impact attenuator principles and categories provided in IDOT specifications. There are many other factors that will influence the selection of an impact attenuator for a given site. Therefore, the designer should only use this figure as a starting point in the comparison and analysis process for selection of the best category.

38-8.10 Temporary Installations

Access to the work site becomes an additional consideration for temporary installations, especially where temporary concrete barriers are used to close a lane or to channel traffic.

Also, in some cases (e.g., stage construction of two-lane bridges) it may be desirable for the impact attenuator to block the closed lane, reducing the likelihood that an errant vehicle could reach the construction area. These competing needs, access and physical closure of the lane, may be mutually exclusive at some sites where shoulders and right of way are restrictive.

Where construction access can be provided on the shoulders or by other available means (e.g., temporary widening, easement), the preferred layout would include concrete barriers and an impact attenuator placed to effectively block the closed lane. The designer should provide necessary plan details to show the positioning of the concrete barrier and impact attenuator devices. If sand module impact attenuators are allowed, the specific required array should be included in the plans along with a notation of the Test Level met by the design. Width restrictions may not allow for angling the array toward traffic. In this case, the array should be installed parallel to the roadway.



Design Speed On Mainline (mph)	Dimensions for Impact Attenuator Reserve Area (feet)								
	Minimum						Preferred		
	Restricted Conditions			Unrestricted Conditions					
	N	L	F	N	L	F	N	L	F
45 or less	7	25	2	9	27	3	12	35	4
over 45	7	38	2	9	40	3	12	45	4

Design Speed On Mainline (km/h)	Dimensions for Impact Attenuator Reserve Area (meters)								
	Minimum						Preferred		
	Restricted Conditions			Unrestricted Conditions					
	N	L	F	N	L	F	N	L	F
70 or less	2.1	7.6	0.6	2.8	8.2	0.9	3.7	10.7	1.2
over 70	2.1	11.6	0.6	2.8	12.2	0.9	3.7	13.7	1.2

RESERVE AREA FOR IMPACT ATTENUATORS

Figure 38-8.E

Operational Principle/ (Pay Item)	Advantages	Disadvantages	Typical Uses*
ENERGY ABSORBING	See Figure 38-8.C.	See Figure 38-8.C.	
Impact Attenuators (Fully Redirective, Narrow) and Impact Attenuators, Temporary (Fully Redirective, Narrow)	1. Prevents encroaching vehicle from traveling behind the impact attenuator. 2. Space efficient. 3. Can fit narrow hazards. 4. Where space permits, connection to a barrier system may allow shielding of wider hazards.	1. Residual capacity after an impact varies among items. 2. Requires anchoring to a slab or pavement. 3. Not suited to wide hazards.	1. Ends of concrete barrier beyond full shoulder width where impacts are expected to be rare. 2. Intermediate width medians, piers. 3. Type D guardrail.
Impact Attenuators (Fully Redirective, Wide), and Impact Attenuators, Temporary (Fully Redirective, Wide)	1. Prevents encroaching vehicle from traveling behind the impact attenuator. 2. IDOT pay items and specifications will cover hazards up to only 90 in (2.25 m) wide. See Section 38-8.06 3. Space efficient.	1. Residual capacity after an impact varies among items in this category. 2. Requires anchoring to a slab or pavement.	1. As above, but for wide hazards (e.g., wide piers) or gore hazards.
Impact Attenuators (Severe Use, Narrow) and Impact Attenuators, Temporary (Severe Use, Narrow)	1. Prevents encroaching vehicle from traveling behind the impact attenuator. 2. May retain significant useful impact capacity after some hits. 3. Space efficient. 4. Can fit narrow hazard.	1. Higher cost than items not requiring severe use characteristics. 2. Requires anchoring to a slab or pavement. 3. Not suited to wide hazards. 4. May rebound a vehicle as the system restores after a frontal hit. This may create secondary collisions with traffic. 5. Requires post impact monitoring to ensure that reusable modules are replaced at the end of their service life.	1. Ends of concrete barrier separating opposing traffic where repeated or frequent hits are expected and/or where it is necessary to keep repair visits and times to a minimum. 2. Narrow medians. 3. Type D guardrail. 4. Roadside concrete barrier or bridge parapet in a temporary application. 5. Other narrow point hazards. This may require limiting the list of devices to those that are free-standing with respect to the hazard.

** See Figures 38-8H and 38-8.I for additional information.*

COMPARISON BY PAY ITEM

Figure 38-8.F

Operational Principle/(Pay Item)	Advantages	Disadvantages	Typical Uses*
ENERGY ABSORBING	See Figure 38-8.C.	See Figure 38-8.C.	
Impact Attenuators (Fully Redirective, Resettable)	1. Requires minimal parts and labor for repairs. Low life-cycle cost where there are occasional to frequent impacts. 2. Prevents encroaching vehicle from getting behind the impact attenuator. 3. Space efficient. 4. Can fit narrow hazard.	1. Initial cost higher than non-premium system. 2. Not required to self-restore after impact. 3. May require a special barrier detail to transition to a wide hazard.	1. As above, but where impacts are expected on an occasional basis. (At least 1 per 3 years, up to 2 per year, depending on accessibility for repairs and impacts to traffic.)
Impact Attenuators (Severe Use, Wide) and Impact Attenuators, Temporary (Severe Use, Wide)	1. May retain significant useful frontal impact capacity after some hits. 2. Space efficient. 3. Can cover a hazard width up to about 90 in (2.25 m).	1. Higher cost than items not requiring severe use characteristics. 2. Requires anchoring to a slab or pavement. 3. May rebound a vehicle as the system restores after a frontal hit. This may create secondary collisions with traffic.	1. Piers or gore areas separating opposing traffic where repeated or frequent hits are expected and/or where it is necessary to keep repair visits and times to a minimum. 2. Narrow medians.
Impact Attenuators (Partially Redirective)	1. Lower cost than fully redirective systems. 2. Suited for direct attachment to Type D guardrail.	1. For narrow hazards. 2. Requires posts to be driven. 3. Lack of reserve impact capacity after a hit.	1. Ends of Type D guardrail separating traffic lanes moving in the same direction, and where impacts are expected to be infrequent. 2. Wide medians, gore areas. 3. Concrete barrier on right side shoulders, or at gores.
Impact Attenuators (Non-Redirective)	See Figure 38-8.C for Sand Modules.	See Figure 38-8.C for Sand Modules.	Point hazards (e.g., piers or sign foundations) not near a travel lane.

**See Figures 38-8.H and 38-8.I for additional information.*

COMPARISON BY PAY ITEM

Figure 38-8.F
(Continued)

Operational Principle/(Pay Item)	Advantages	Disadvantages	Typical Uses*
MOMENTUM TRANSER	See Figure 38-8.C.	See Figure 38-8.C.	
Impact Attenuators Temporary (Non-Redirective)	See Figure 38-8.C.	1. Area for application must have enough room to accommodate either the sand modules or the water filled impact attenuator (ABSORB 350). 2. Applies principally where it will shield end of a temporary concrete barrier.	1. Ends of concrete barriers or other hazards well off the traffic lane, and where it is acceptable to allow a vehicle to encroach behind the device. 2. See Highway Standards 701321 and 701402.

**See Figures 38-8.H and 38-8.I for additional information.*

COMPARISON BY PAY ITEM

Figure 38-8.F
(Continued)

Where shoulders of sufficient width or other means of access are not available, the designer can arrange the concrete barriers according to the minimums shown on the *Illinois Highway Standards* and choose among the various pay items for temporary impact attenuators, as appropriate for the site and traffic. This will allow the contractor a range of options to weigh for access, cost and maintenance factors.

38-8.11 Additional Guidance

Figure 38-8.G proves a partial review and comparisons of the attributes for the various Department approved systems. Figures 38-8.H and 38-8.I correlate the various systems to the contract pay items.

System	Non-Redirective	Partially Redirective	Fully Redirective	Resettable	Residual Capacity	Narrow Only	Connects To:	Bidirectional? (Y/N)	Length** (Test Level 3)	Length ** (Test Level 2)	Min Width (Out to Out)*	Max Width*	Notes
Quadguard			X			Up to 90″	Generic	Y	23′-11″	12′-9″	2′-7″	90″	Requires paved pad.
Quadguard Elite			X		X	Up to 90″	Generic	Y	35′-6″	23′-11″	2′-7″	90″	Requires paved pad.
Quadguard LMC			X		X	Up to 90″	Generic	Y	35′-6″	23′-11″	3′-7″	90″	Requires paved pad.
CAT-350		X				X	Guardrail or Concrete Barrier	Y	31-3″	N/A	2′-7″	2′-7″	Installs with driven posts
REACT 350			X	X	X	Up to 120″	Generic	Y	31′-1″	22′-1″	3′-8″ base, and 3′ cylinders	120″	Requires paved pad.
Brakemaster 350		X				X	Guardrail or Concrete Barrier	Y	31′-6″	N/A	2′-1″	2′-1″	Installs with driven posts.
TAU-II			X			Up to 96″	Generic	Y	26′-11″	15′-5″	2′-11″	8′-8″	Requires paved pad.
FLEAT MT		X				X	Guardrail or Concrete Barrier	Yes - but intended for wide median	37′-6″	25′	Match Type D Guardrail	Match Type D	Installs with driven posts.
TRACC			X			X	Generic	Y	21′	14′	2′-7″	4′-10″ (See Note)	Requires paved pad.
QUEST			X			X	W-beam, Thrie beam, Concrete barrier, or vertical concrete barrier	Y	18′-10″	N/A	2′-0″	2′-0″	Requires paved pad at front and rear.
SAND MODULES	X						Generic		Varies	Varies	6′	Unlimited	Requires paved pad.
ABSORB 350	X					X	Temporary Concrete Barrier	Y	26′-9″	19′-¼″	2′-0″	2′-0″	Does not require paved surface.
SCI 100GM			X	X		X	Generic	Y	21′-6″		3′-1-7/16″	3′-1-7/16″	Requires paved pad.

Notes:

The TRACC may be widened. At it's nominal length and at Test Level 3, the maximum width is 58 in (1.47 m). Additional width may be gained in approximately 6½ in (165.1 mm) increments by the addition of 28 in (711 mm) extension wings.

* *The minimum widths shown are nominal out-to-out of the impact attenuator. The various backup systems, transition pieces, etc., are considered part of the impact attenuator, and are to be considered part of the pay item.*

Maximum widths are out-to-out if same as minimum, or maximum width of hazard to be shielded, if greater than the shown minimum. This applies to the impact attenuator only. Additional width may be gained by attaching to approved barriers and applying approved flare rates to wide hazards. This application will be limited by available longitudinal space.

** *Exclusive of any special transitions or connections.*

ATTRIBUTES OF IMPACT ATTENUATORS

Figure 38-8.G

Systems and Allowable Products to Fit Needs	Typical Applications
IMPACT ATTENUATORS (FULLY REDIRECTIVE, NARROW) Quadguard Quadguard Elite Quadguard LMC REACT 350 TAU-II family TRACC family SCI-100GM QUEST	1. Where the expected rate of crashes involving the system are rare to infrequent (less than 1 crash per 3 years). 2. *Narrow Median (< 40 ft (12 m)). 3. Narrow Hazard, Concrete Barrier, Narrow Pier. 4. End of Median Barrier or Type D Rail. 5. Alignment or traffic operations do not contribute to added likelihood of run off the road incidents.
IMPACT ATTENUATORS (FULLY REDIRECTIVE, WIDE) Quadguard Quadguard Elite Quadguard LMC React 350 TRACC family TAU-II Universal	1. *Narrow Median (< 40 ft (12 m)). 2. Up to 90 in (2.25 m) Wide Hazard, Sign Base, Pier, etc. 3. Narrow gap between bridges. 4. Alignment or traffic operations do not contribute to added likelihood of run off the road incidents. 5. Hazards where space does not allow development of width transitions from other impact attenuators.
IMPACT ATTENUATORS (FULLY REDIRECTIVE, RESETTABLE) REACT 350 SCI-100GM	1. Where crashes are expected to be more than 1 per 3 years. 2. Similar locations to Fully Redirective, Narrow.
IMPACT ATTENUATORS (SEVERE USE, NARROW) Quadguard Elite REACT 350 Quadguard LMC	1. *Narrow Median(< 40 ft (12 m)). 2. Expect repeated impacts (> 2/yr). 3. Narrow Hazard, Concrete Barrier, Narrow Pier. 4. End of Median Barrier or Type D Rail. 5. Outside of curves, areas near weaving, lane drops. 6. Near entrances/exits on freeways/ expressways. 7. Also appropriate on outside shoulder hazards where repeated impacts and traffic levels make continued capability and ease of repairs critical.
IMPACT ATTENUATORS (SEVERE USE, WIDE) Quadguard Elite REACT 350	1. *Narrow Median(< 40 ft (12 m)) 2. Expect repeated impacts. 3. Up to 90 in (2.25 m) Wide Hazard, Sign Base, Pier, etc. 4. Narrow Gap Between Bridges. 5. Outside of curves, areas near weaving, lane drops. 6. Near entrances, exits on freeways/ expressways. 7. Also appropriate on outside shoulder hazards where repeated impacts and traffic levels make continued capability and ease of repairs critical. 8. Hazards where space does not allow development of width transitions from other impact attenuators.
IMPACT ATTENUATORS (PARTIALLY REDIRECTIVE) *CAT 350 *Brakemaster 350 *FLEAT MT	1. Outside Shoulder, Gore Area. 2. Narrow Hazard, Pier, Barrier Wall, D Rail. 3. Separation of lanes moving in same direction. 4. Expected low frequency of hits.
IMPACT ATTENUATORS (NON-REDIRECTIVE) Fitch Universal Module System Energite III Big Sandy Sand Barrels	1. Outside Shoulder, Gore Area, Wide Median. 2. Sign Support, etc. 3. Separation of lanes moving in same direction, or where there is a wide separation.

Note: The TRACC may be widened. At its nominal length, the maximum width is 58 in (1.47 m). Additional width may be gained in approximately 6½ in (165.1 mm) increments by the addition of 28 in (711 mm) extension wings.

** See Figure 6.1 of the 2002 AASHTO Roadside Design Guide. Median barriers are warranted somewhere between 30 ft and 50 ft (9 m and 15 m) depending on traffic. This is a reasonable estimate to avoid having errant vehicles gate through.*

Use of standard barrier sections and approved flare rates may allow installation of narrow impact attenuators in advance of wide hazards, depending on space available.

IMPACT ATTENUATORS – PERMANENT INSTALLATIONS

Figure 38-8.H

Systems and Allowable Products to Fit Needs	Typical Applications
IMPACT ATTENUATORS, TEMPORARY (FULLY REDIRECTIVE, NARROW) Quadguard CZ Quadguard LMC Quadguard Elite REACT 350 TRACC Family TAU-II Family SCI-100GM	1. Locations where the rate of crashes is expected to be less than 1 per 3 years, and first costs control.** 2. *Narrow median locations. 3. Temporary locations where errant vehicles must not encroach behind the device. 4. Head to head traffic. 5. Severe hazards beyond the device.
IMPACT ATTENUATORS, TEMPORARY (FULLY REDIRECTIVE, WIDE) Quadguard Elite Quadguard LMC REACT 350 TRACC Family	1. Similar to locations for Fully Redirective, Narrow, but where the hazard is wide.
IMPACT ATTENUATORS, TEMPORARY (FULLY REDIRECTIVE, RESETTABLE) REACT 350 SCI-100GM	1. Where crashes are expected to be more than 1 per 3 years and life cycle costs control.** 2. Similar to locations for Fully Redirective, Narrow.
IMPACT ATTENUATORS, TEMPORARY (NON-REDIRECTIVE) Fitch Universal Module System Energite III Big Sandy Sand Barrels ABSORB 350	1. Temporary locations where errant vehicle may continue behind the crash cushion. 2. See Highway Standards 701321 and 701402 as site conditions permit.
IMPACT ATTENUATORS, TEMPORARY (SEVERE USE, NARROW) Quadguard LMC Quadguard Elite REACT 350	1. *Narrow median locations. 2. Temporary locations where frequent impacts are expected and/or where access for repairs would create unacceptable traffic control or operational problems. These systems are fully redirective. This must be acceptable at the site.
IMPACT ATTENUATORS, TEMPORARY (SEVERE USE, WIDE) Quadguard Elite REACT 350	1. Similar to locations for Severe Use, Narrow, but where the hazard is wide.

* *See Figure 6.1 of the 2002 AASHTO Roadside Design Guide. Median barriers are warranted somewhere between 30 ft and 50 ft (9 m and 15 m) depending on traffic. This is a reasonable estimate to avoid having errant vehicles gate through.*

** *Generally, life cycle costs are the responsibility of the contractor for temporary installations.*

IMPACT ATTENUATORS – TEMPORARY INSTALLATIONS

Figure 38-8.I

38-9 REFERENCES

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